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WASHITA RIVER BASIN WATER USE AND POLLUTION REPORT

Public Health Service
Little Rock, Arkansas

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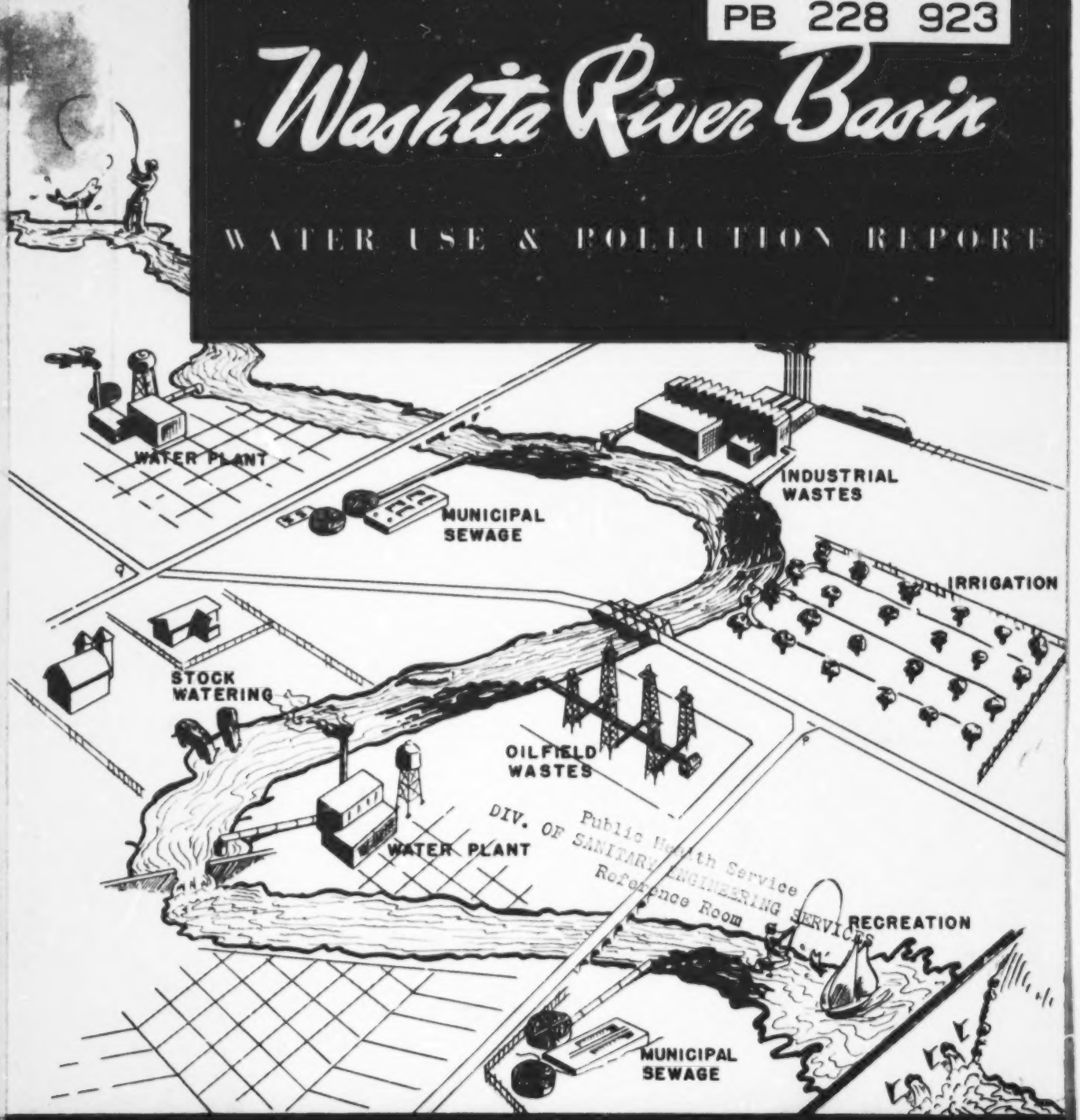
Washita River Basin

WATER USE & POLLUTION REPORT



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INTRODUCTION

Stream pollution in the Washita River has received considerable attention, especially during recent years. Water resources are limited, and in some places critical water shortages occur from time to time. It is important that present water resources be protected from pollution and that efforts be made to obtain additional supplies in the critical areas in order to provide suitable water for public and industrial water supplies, agriculture, propagation of fish and aquatic life, recreational purposes, and other legitimate uses.

This report presents information about the ways the water resources of the basin are used, the pollution entering those water resources and the resulting damages, the benefits which may result from pollution prevention and abatement, pollution prevention measures now in effect, and those which appear to be needed.

Data on which this report is based have been compiled through, and in cooperation with, the state and Federal agencies which are concerned with the conservation and development of the water resources in the State. Deficiencies in data and the gaps in information indicated in the report are as significant as the presentation of available facts and statistics. They indicate the work that still needs to be accomplished by water pollution control authorities for the preparation of comprehensive programs. Corrective measures that are needed now to improve the chemical and sanitary quality of the surface and underground water are shown in Table L of this report.

This report also represents the efforts by the Public Health Service, which is required by provisions of the Federal Water Pollution Control Act, Public Law 845, passed by the 80th Congress in June 1948, to cooperate with other Federal agencies, with state and interstate water pollution control agencies, and with municipalities and industries in the preparation or adoption of comprehensive programs for eliminating or reducing the pollution of interstate waters and tributaries thereof, and improving the sanitary condition of surface and underground waters.

A sincere effort has been made by all who contributed to this report to present a fair picture of the complex water pollution problems in the Washita Basin and to present reasonable conclusions and recommendations. It is our hope that this report, as a step in the cooperative development of an ultimate comprehensive water pollution control program, will help in safeguarding the water resources of the Washita Basin.

ACKNOWLEDGEMENTS

This report has been prepared jointly by the Bureau of Sanitary Engineering of the Oklahoma State Department of Health and the Southwest-Lower Mississippi Drainage Basin Office, Division of Water Pollution Control, Public Health Service.

Acknowledgement is made to the Oklahoma Planning and Resources Board, Division of Water Resources, for their special efforts in providing information on pollution from oil fields and refineries.

Published reports and other information compiled by the following State and Federal agencies have been used as sources of reference for much of the descriptive material in this report.

State Corporation Commission
University of Oklahoma, Bureau of Business Research
State Game and Fish Department
U. S. Department of Commerce
  Weather Bureau
  Bureau of the Census
U. S. Department of the Interior
  Geological Survey
  Bureau of Reclamation
U. S. Department of the Army
  Corps of Engineers

SUMMARY

The Washita River Basin extends diagonally across Oklahoma from Hemphill County in the Panhandle of Texas southeasterly to Lake Texoma. The lower section of the Washita River forms an important arm of the Lake.

The basin is 270 miles long and varies from 25 to 50 miles in width. It contains an area of 7945 square miles, of which 440 square miles, or about six percent of the basin is in Texas. The Washita River in the Texas portion of the basin has intermittent flows and is considered of minor importance. The three small communities in the Texas portion of the basin are not dependent upon the Washita River for water supply or waste disposal.

The main stem of the Washita River has a total length of 652 miles, and many additional miles of streams are included in numerous major tributaries.

The western half of the Washita Basin is semi-arid and includes the sand hills in Texas and a portion of the rolling plains or redbeds in Oklahoma. The eastern half of the basin includes rolling plains, the Arbuckle mountains, and the Gulf coastal plains. The uplands comprise a large portion of the basin and are generally of rolling to rough topography. Erosion has been severe on much of the land, and considerable valuable topsoil has been lost. The valleys consist of terrace lands and flood plains, which vary in width from one-fourth mile to two miles.

The average yearly rainfall varies from 23 inches in the western portion of the basin to 39 inches in the eastern part, but great fluctuations in the annual rainfall occur from year to year. Crop yields are frequently reduced due to inadequate rainfall. Intense rainfall of the cloudburst type occurs and occasionally crops may be damaged in the same growing season by floods and drought.

The average growing season varies from 200 days in the western sections to 230 days in the eastern portion of the basin.

Cattle raising was largely responsible for the early settlements in the basin. As early as 1865 white settlers leased land from the Indians for cattle grazing. Today, livestock production and other agricultural activities provide the major portion of employment and income in the basin. Oil and gas production has increased in recent years, but the percentage of persons employed in this industry is small in comparison to the percentage of persons employed in farming and other activities associated with agriculture.

The water resources are an important asset to the basin and are used mainly for public and industrial water supplies, agriculture, fishing and other recreational activities.

Thirty-five municipalities have public water supplies derived from the ground and surface water resources of the basin. Eight of the public water supplies obtained from surface waters serve 70,000 persons, or 65 percent of the total population served by municipal systems. The sources of surface supplies are from streams and impoundments; two of these supplies are supplemented by ground water.

Industrial water supplies are derived mainly from ground water sources. The larger quantities are used by refineries, gasoline plants, and gas compressor stations. Railroads use appreciable quantities of water from several tributaries in the southeast portion of the basin.

Irrigation is limited to the flood plains and to the regions in which stream flows are sufficient to supply water during the prolonged dry spells. The waters from the Washita River system are used extensively for watering cattle that are raised throughout the basin.

Sport fishing along the Washita and the major tributaries provides recreational opportunities for residents of the region. Commercial fishing is important in the lower reaches of the river and in Lake Texoma.

Pollution entering the Washita consists of municipal and industrial wastes, sediment from eroded land, and minerals that are dissolved by surface run-off and streams flowing over natural mineral deposits, particularly gypsum.

Thirty municipalities with a total population of 62,400, including three state institutions, are regarded as sources of pollution in the basin. Two of these municipalities, Cheyenne and Kingston, at present do not have sewer systems, but construction is contemplated in the near future. Small industrial plants discharge wastes into several municipal sewer systems, but in few cases do the industrial wastes materially increase the total waste load of the individual community.

Sources of industrial pollution considered in this report include 13 oil and gas fields and two refineries. Wastes from the oil fields consist principally of brines and some waste oil. The two refineries contribute both organic and inorganic wastes to the streams. The amount of wastes from these industrial sources is undetermined.

Silt pollution is a serious problem in the basin. Erosion of farm lands carries away valuable soil, reduces crop production, destroys grazing areas, and results in general deterioration of the lands. Stream bank erosion contributes significantly to the sediment loads in the streams. Bridges have been washed out or by-passed as a result of shifted streams caused by deposition of sediment in the main channel. Deposition of sediment on flood plains causes damage to tillable lands and crops. Sediment damages the

streams for fish and other aquatic life by covering the stream bottoms that normally provide an environment suitable for habitation, reporduction, and feeding. In addition, the turbidity resulting from sediment in the streams reduces the production of algae and other green plants which are an important food supply for the aquatic life. Reduction of plant and animal life, in turn, reduces the capacity of the stream to absorb pollutants.

Pollution abatement will result in numerous direct and indirect benefits. The specific or tangible benefits are those associated with municipal and industrial water supply, agricultural uses, and fish and game propagation. The indirect benefits, to which a monetary value cannot be assigned, include benefits to public health, recreation, and improvements in the natural aesthetic quality of the watercourses.

Pollution abatement facilities are available in 26 of the 30 municipalities considered in this report. Municipal waste treatment plants, providing various degrees of treatment, serve 49,900 or 80 percent of the total population affected in the 30 municipalities. Seventeen of the 26 municipalities provide primary treatment for 16,500 persons, and nine municipalities provide secondary treatment for 33,400 persons. Of the four communities without treatment plants, three are constructing plants and one is planning for the construction of needed works. Present treatment facilities employed by the 26 communities reduce the total pollution load, in terms of equivalent number of people, from 60,800 to 29,200, representing an average reduction of 50 percent. Included in the category of municipal sewage are wastes from a number of small industries such as general food and dairy products processing plants, produce packing, and others associated with agricultural products.

Information regarding the adequacies of existing municipal treatment facilities shows that 23 or the 26 treatment plants do not have adequate capacity. Six plants have satisfactory operation; 15 are operated unsatisfactorily; and the operation of five plants is undetermined.

Construction of municipal treatment plants has been gradual. One plant constructed in 1948 and another constructed in 1949 were designed to provide treatment for a total population of 24,000. Three plants now under construction have been designed to provide treatment for an additional 21,000 persons.

New treatment plants, enlargements, or other improvements are needed for 28 of the 30 municipalities considered as sources of pollution. Five new plants, three of which are under construction, are needed in communities that have a total sewered population of 13,100; enlargements or additions are needed at 15 existing plants serving 25,500; and eight treatment plants need replacement. These project needs affect 73 percent of the sewered population in the basin.

Of the 15 major sources of industrial pollution, nine oil fields provide facilities for disposal of part or all wastes. Six sources of pollution, including two refineries, discharge untreated wastes to the watercourses. The existing brine disposal systems for three oil fields are of adequate capacity, but the facilities at six fields are inadequate for complete disposal of all wastes. Operation of all existing oil field wastes disposal systems is regarded as satisfactory.

Pollution abatement needs of industries include five new treatment facilities and enlargements or additions to six existing facilities. The needs of one industry is undetermined. Three of the industries are actively planning facilities for pollution abatement, and the current status of action by nine industries is undetermined.

Soil conservation interests are carrying on active programs for control of soil erosion in the basin. The Washita Basin is one of eleven demonstration areas in the United States where experimental soil conservation practices have been instituted.

At present there is no administrative body responsible for coordinating the efforts of the four separate state agencies that have authority to control or abate pollution. Plans for coordination of water pollution control activities among the separate state agencies are being formulated by meetings of representative officials in an attempt to define the administrative authority and responsibility of each agency. This action may later lead to consideration of legislation to clarify administrative procedures for water pollution control.

Public support is essential for the promotion of an effective water pollution control program. An expanded educational program presenting various aspects of the water pollution control program to the general public is considered necessary. As part of this educational program, the State Department of Health has made available for public distribution several pamphlets advertising the water pollution problem and its abatement in the state.

It is estimated that the initial cost for providing municipal waste treatment facilities needed for pollution abatement in the basin will be approximately $1,000,000. The estimate does not include consideration of cost for needed industrial waste disposal facilities.

CONCLUSIONS

(1) The waters of the Washita River system are used primarily for public and industrial water supplies, livestock watering, irrigation and for limited recreational purposes. The waters are also used for final disposal of wastes from municipal and industrial sources.

(2) Limited water resources and pollution from natural sources in the form of sediment, and dissolved salts and minerals, add to the man-made pollution conditions and give rise to serious problems of water use.

(3) A significant number of municipalities and several industries in the basin have waste treatment facilities. The adequacy of the existing facilities, however, is generally deficient and a large percentage of existing plants require improvements for the abatement of pollution and protection of the streams. About 88 percent of the municipal plants are overloaded or otherwise inadequate, and about 58 percent are not operated satisfactorily.

(4) Gradual progress in abatement of pollution is evidenced by the completion and beginning construction of five municipal treatment plants during the past five year period. Accomplishments in disposal of oil field wastes are also apparent although information regarding the scope of the activities is not complete.

(5) Full benefit can be derived from existing plants and from facilities constructed in the future by expanding the program activities of the State Department of Health to provide for more complete surveillance of treatment plant operation and to increase activities for training of plant operators.

(6) The benefits resulting from a program of pollution control will affect all legitimate water uses. Prevention and abatement of pollution by construction of needed waste treatment facilities, supplemented by increased flows from water conservation and flow regulation projects, will permit a more complete utilization of the water resources for all desireable uses.

(7) The deficiencies of information and gaps in data indicated throughout the report are as significant as the presentation of available facts and statistics. They indicate the work which still needs to be accomplished by water pollution control authorities to define completely the scope of the pollution problem.

(8) Pollution control has been handicapped, to an extent, by divided responsibility and administration of existing state water pollution control laws among the several departments of the state government. The administration of a broad water pollution control program could be strengthened by providing legislative mechanism whereby the efforts of all agencies concerned could

be coordinated for a unified approach to the solution of the pollution problems.

(9) A preliminary estimate, based on data available, indicates that the initial cost for needed municipal waste treatment plants will be approximately $1,000,000. It is reasonable to assume that re-evaluation of the needs, when more complete data become available, may change this figure appreciably. The estimate presented above does not include consideration of cost for providing needed industrial waste treatment facilities.

(10) Pollution abatement in the Washita Basin is not an objective to be attained by legal prosecutions and attempts to make regulations so strict that industry will be forced out of business or that undue financial hardship be placed on municipalities. The need for pollution control is urgent if the region is to continue to progress, because the water resources must be used wisely to meet the needs of an expanding economy. It follows then that pollution control is an objective to be attained through a sequence of logical and reasonable measures.

RECOMMENDATIONS

It is recommended that:

(1) All state agencies charged with water pollution control, coordinate activities to assure that all sources of pollution are adequately controlled and that the program of each agency complements and aids that of other agencies concerned.

(2) Continued efforts should be made by the responsible state agencies to secure supplemental data, particularly on industrial waste pollution, for the purpose of defining the problems more completely and to permit evaluation of the needs for instituting reasonable corrective measures.

(3) Municipalities and industries assume their responsibility for abating pollution in the waters of the basin and initiate construction of needed projects as outlined herein.

(4) An examination be initiated of the present municipal tax structures as related to financing of waste treatment and related public works. The review should accomplish an evaluation of the existing financing methods for the purpose of enacting supplemental enabling legislation to assist the municipalities in financing needed facilities.

(5) Program activities of the State Department of Health be expanded to provide for more complete surveillance of treatment plant operation and to increase activities for training of plant operators.

(6) Public educational programs sponsored by the responsible state water pollution control agencies be expanded as a means of publicizing the extent of pollution in the basin and informing the public of the damages resulting from pollution and benefits to be derived from pollution abatement.

(7) Existing soil and water conservation control programs in the basin be expanded and accelerated for the purpose of accomplishing abatement of silt pollution and reduction of gross mineralization now affecting all primary water uses.

HISTORICAL BACKGROUND

Prior to 1800, roving plains Indians and fur traders were the only inhabitants of the Washita Basin. Eastern Indian tribes moved into the Indian territory between 1830-1880, and the first non-Indian settlements were trading posts and military forts. Fort Washita was established in 1842 about 22 miles above the mouth of the Washita River. Fort Arbuckle was established in 1851 in Murray County near Wildhorse Creek, and Fort Cobb was established in 1859 at the mouth of Pond (Cobb) Creek.

About 1865 the cattle industry became an important factor in the settlement of the area. Vast herds of cattle accumulated in Texas during the Civil War. These were collected and driven over the Old Chisholm Trail, now Highway 81, to shipping points in Kansas. The excellent grazing lands in Oklahoma induced ranchers to lease grassland from the Indians for livestock production.

Allotments of land to white settlers were made in 1892 in Roger Mills, Custer, and Washita Counties as a result of the passage of the Organic Act in 1890. The Kiowa-Comanche opening in 1901 started the settlements in Caddo, Kiowa, and Comanche Counties. Other areas in the Washita Basin were alloted to white settlers after Oklahoma gained statehood in 1907.

Towns grew in the basin where trading posts and military forts had been established and as the need arose for agricultural marketing and supply centers.

Among the first communities in the basin to establish water systems were Ardmore and Chickasha. In January of 1903, Ardmore acquired 1260 acres of land northwest of the town and constructed a 150-acre lake by impounding Caddo Creek, a tributary of the Washita River. Raw water was piped to the city and used untreated until 1918 when a filtration plant was constructed.

The water supply of Chickasha was also constructed in 1903. Water was taken from the Washita River and pumped to the city without treatment by two 600 g.p.m. steam pumps. In 1906 an elevated storage tank was constructed, and additions were made to the distribution system. The present treatment plant was built in 1931. Money is available and plans have been made to improve and enlarge the present water treatment facilities.

The Southern Indians, Cherokees, Creeks, Choctaws, Chickasaws, and Seminoles, were alloted land in Oklahoma by the Federal government in the early 1800's. The first discovery of oil by them is not recorded, but in 1846 Agent A. M. Upshow of the Chickasaws mentioned "Medicine Springs" in his report to the Commissioner of Indian Affairs; and two years later he referred to them, saying that one of them was an oil spring, the oil from

which both Indians and Texans used for medicine. In 1853 Agent A. J. Smith, who had succeeded Upshow, stated that the oil springs at the foot of the Wichita Mountains on the Washita River were visited by a great many Texans and some from Arkansas, and that the oil serves as a remedy for all chronic diseases including rheumatism and dropsy. The first oil field in the Washita Basin was opened in 1904 and is known as the Wheeler pool although Oil City is the name of the town in the field in Carter County. The discovery well was drilled by the Santa Fe Railway Company in May, 1904. Since the discovery, many wells in the pools have been completed as combination oil and gas wells. The second oil field was opened in Stephens County in 1907. Although drilling in the Cruce pool was started in 1907, the first wells were not completed until 1912 when the Washita Gas and Fuel Company brought in a million cubic-foot gas well at a depth of 850 feet. The first wells supplied the towns of Duncan and Marlow for many years with natural gas. Date and location of discovery wells in the early development of oil in the Washita Basin are shown in Table 1.

TABLE 1

OIL FIELDS

WASHITA RIVER BASIN

Field	County	Location	Date and Location of Discovery Wells	
Baird	Stephens-Cotton	T.1S, R.9W	1919	Not given.
Bayou	Carter	T.5S, R.2W	1921	Hewitt area.
Brock	Carter	T.5S, R.1E	1922	Not given.
Cement	Caddo	T.5-6N,R.9-10W	1914	3 miles east of Cement.
Chickasha	Grady	T.5N, R.8W	1922	Sec. 26, T.5N, R.8W.
Comanche	Stephens	T.2S, R.7-8W	1918	Sec. 20, T.2S, R.7W.
Cox	Carter	T.2S, R.2W	1925	Cox farm.
Cruce	Stephens	T.1N, R.5-6W	1907	Sec. 12, T.1N, R.6W.
Doyle	Stephens	T.1N, R.5W	1922	Sec. 11, T.1N, R.5W
Duncan	Stephens	T.1S, R.8-9W; T.1N, R.8-9W	1919	Sec. 30, T.1S, R.8W.
Empire	Stephens	T.1S, R.8-9W	1920	Sec. 33, T.1S, R.8W.
Fox	Carter	T.2S, R.3W	1917	Sec. 29, T.2S, R.3W.
Gotebo	Kiowa	T.7N, R.16W	1908	10 miles west of Washita Uplift.
Graham	Carter	T.2-3S, R.2-3W	1917	Sec. 32, T.2S, R.2W.
Harness	Grady	T.5N, R.7W	1925	No information.
Healdton	Carter	T.3-4S,R.2-3-4W	1933	No information.
Hewitt	Carter	T.4S, R.2W	1919	No information.
Homer	Carter	T.1S, R.2W	1916	No information.
Kilgore	Grady-Stephens	T.3N, R.5W	1919	North of Kilgore-County Line.
Knox	Stephens	T.2N, R.5W	1916	No information.
Loco	Stephens	T.3S, R.5W	1913	Sec. 13-14, T.3S, R.5W.
Magnolia	Stephens	T.1S, R.9W	1918	Sec. 22, T.1S, R.9W.
Milroy	Stephens	T.2S, R.4W	1916	No information.
Nellie	Stephens	T.2N, R.9W	1925	Sec. 26, T.2N, R.9W.
Rainola	Stephens	T.1S, R.8W	1921	Sec. 22, T.1S, R.8W.
Robberson	Garvin	T.1N, R.3W	1920	Sec. 14, T.1N, R.3W.
Round-Up	Carter	T.2S, R.2W	1926	3 wells.
Sayre	Beckham	T.9N, R.23W	1922	Sec. 15, T.9N, R.23W.
Shulem-Mechem	Carter-Stephens	T.1-2S, R.3-4W	1923	Sec. 28, T.1S, R.3W.
Tatums	Carter	T.1S, R.3W	1927	Sec. 14, T.1S, R.3W.
Velma	Stephens	T.1-2S, R.4-5W	1917	Sec. 36, T.1S, R.5W.
Wheeler	Carter	T.3S, R.2W	1904	Sec. 21, T.3S, R.2W.
Wildcat-Jim	Carter	T.2S, R.2W	1914	Sec. 18, T.2S, R.2W.
Woolsey	Stephens	T.2S, R.6W	1922	Sec. 23, T.2S, R.6W.

Information taken from Oklahoma Geological Survey Bulletin 40, Vol. 1.

PHYSICAL DESCRIPTION

General

The Washita River Basin lies in southwest Oklahoma and is bounded on the north by the South Canadian River watershed and on the south by the Red River watershed. The river system drains an area of 7945 square miles, of which 440 square miles, or about six percent, lie in the Texas Panhandle. The Washita River is approximately 650 miles long. It flows in an easterly direction from Hemphill County, Texas, through the Texas Panhandle, and western part of Oklahoma. From Pauls Valley, Oklahoma, it flows in a southeasterly direction and empties into Lake Texoma. The Washita River, unlike the rivers to the north of it which flow through wide, sandy flood plains, has a generally narrow channel with steep banks and wide, fertile flood plains.

The western half of the watershed is in the semi-arid plains region of Texas and Oklahoma. This region includes the sand hills area along the upper reaches in Texas and the red beds in Oklahoma. The eastern half of the basin consists mainly of the rolling plains of central Oklahoma, with the Arbuckle Mountains of Johnston and Murray Counties and the comparatively small Gulf coastal plain area in the lower part of the basin.

Elevations of the drainage basin vary from about 3,000 feet above sea level near its source in Roberts County, Texas, to about 600 feet above sea level at Lake Texoma. The slope of the river varies from 30 feet per mile near its source to three feet per mile at Cordell (river mile 345). Below Cordell the slope varies from 1.5 to 3.5 feet per mile. The average width of the valley, from the head to Anadarko, is one-fourth to one-half mile; from Anadarko to Chickasha, one-half to two and one-half miles; below Chickasha, from very narrow to two and one-half miles.

Approximately 48 percent of the watershed is in crops; 36 percent is open grassland; 11 percent is grazing land; and the remaining five percent is in woodland and miscellaneous uses.

Serious flood problems exist in the basin, affecting about 140,000 acres of land. Floods cause damage to farms, transportation facilities, urban developments, and other improvements. The principal areas subject to damages by floods are in the vicinity of Fort Cobb, Chickasha, and Pauls Valley.

The principal tributaries of the Washita River are Barnitz Creek, Rainy Mountain Creek, Sugar Creek, Little Washita River, Rush Creek, Wildhorse Creek, and Caddo Creek.

Geology

In the Washita River Basin the bedrocks range in age from pre-

Cambrian to Tertiary, inclusive. The oldest rocks are exposed in the Arbuckle Mountains and include granite, very thick limestones, dolomites, sandstone, and shale. The limestones and sandstones are good aquifers, and the region abounds with springs issuing from them.

To the southeast, in Marshall, Bryan, and southern Johnston Counties, Coastal Plain deposits, consisting of sand, shale, and limestone of Cretaceous age overlap the south flank of the Arbuckle Mountains. Of these units the Trinity sand at the base is the only important aquifer. Southwest of the Arbuckle Mountains there is a great thickness of shale with some sandstone which is of little importance as a source of ground water. Permian rocks overlap the western part of the Arbuckle Mountains and underlie the entire basin upstream to the Texas-Oklahoma state line. These rocks are mainly shale, but the Rush Springs sandstone is an important aquifer in Caddo and Grady Counties. The overlying Cloud Chief formation which crops out widely in Washita, Custer, and Roger Mills Counties contains much gypsum. A small area in southwestern Roger Mills County is underlain by sand, gravel, clay and caliche, of Tertiary age, from which moderate quantities of ground water of good quality generally may be obtained.

Alluvium underlies the flood plain of the Washita River, which in places is as much as five miles wide. So far as yields are concerned, the alluvium is a good aquifer; but the contained water is highly mineralized, at least as far downstream as Pauls Valley. Small, scattered patches of alluvial materials on high-level terraces are of little value as sources of ground water.

In the western part of the basin much gypsum, and some salt, is included in the Cloud Chief formation. These soluble minerals render both surface and ground water highly mineralized and adversely affect the quality of the water in the basin most of the way to the mouth of the stream.

Climate

The climate of the Washita Basin varies from semi-arid in the western region to semi-humid near the mouth of the river. The average annual rainfall for the area is about 29 inches. It varies from about 23 inches in the western portion to about 39 inches in the eastern part. Approximately 80 percent of the yearly precipitation occurs during the growing season from March through October. The rains occurring during the late summer and early autumn are usually local and are of high intensity-short duration type.

Normally the average rainfall is sufficient to make the major portion of the basin a productive agricultural area without resorting to irrigation. Irrigation is practiced, however, on a limited scale in the western portion during hot, dry summers. Occasional hot winds, which are damaging to crops, are characteristic of the far western section of the Washita Basin.

The average annual snowfall throughout the basin varies from approxi-

mately 14 inches in the western portion to four inches in the lower eastern portion.

The average annual temperature of the basin varies from approximately 59°F. in the upper region to 63°F. near the mouth of the river, and the average length of growing season varies from six and one-half months in the western portion to seven and one-half months in the eastern portion. The winters are usually mild and of short duration.

A summary of the climatological data for the basin is presented in Table 2.

Hydrology

Average annual run-off from the watershed probably does not exceed 50 percent of the rainfall. The greatest run-off occurs during the spring months when the rainfall is the heaviest and evaporation losses are at a minimum.

The flow in the Washita is erratic, varying from flash floods to long periods of very low flow. Fifty percent of the total annual flow occurs in April, May, and June; and less than 20 percent of the flow occurs during July, August, and September. Except for the extreme upper reaches of the river, the run-off is rapid. The rapid run-off usually carries heavy silt loads, and during floods undercutting of the banks occurs along the entire length of the river. Straightening the channel of the Rush Creek tributary has created a problem in bank stabilization on that stream.

Stream flow data for selected gaging stations on the main stem of the Washita River and several tributaries are shown in Table 3. Table 4 shows the duration of minimum flows at several gaging stations in the streams.

In the High Plains region of the Texas Panhandle and in the extreme western part of Oklahoma good ground water supplies are obtained from Tertiary and Quaternary sand deposits. Eastward throughout most of the remaining basin physical conditions are usually not conducive to the occurrence of satisfactory ground water supplies. In the Arbuckle Mountains the Arbuckle limestone is the principal source of ground water; and good yields, although hard, are obtainable. In the deeper formations the water is highly mineralized. The Trinity sands of the West Gulf Coastal Plain yield moderately large supplies of soft water. Through the entire length of the main valley the alluvium is an important source of ground water for many towns. In general, the quality of water obtained from this source is inferior and often requires extensive treatment.

The water of the Washita River is excessively hard due to dissolved gypsum and is an unreliable source of water because of extended periods of low flows. Some of the tributary streams carry water of relatively good

TABLE 2

CLIMATOLOGICAL DATA

Washita River Basin

Location	Elevation - Mean Sea Level	Average Annual Precipitation		Average Annual Temperature	
		Years of Record	Inches	Years of Record	°F
Anadarko	1,206	13	27.4	17	61.5
Carnegie	1,500	34	28.66	34	61.5
Cheyenne	2,000	25	25.82	-	-
Chickasha	1,091	47	30.81	47	60.7
Clinton	1,517	11	29.24	11	59.4
Cordell	1,532	11	26.32	11	60.8
Fort Cobb	1,255	4	28.35	-	-
Hammon	1,700	34	25.64	34	59.8
Lindsay	982	8	36.33	-	-
Madill	770	11	40.76	11	63.1
Marlow	1,292	47	32.93	47	61.4
Pauls Valley	880	49	35.06	49	61.7
Sulphur	1,011	31	38.45	31	63.0
Tishomingo	670	45	38.09	-	-

Data from: "Climatological Data, Oklahoma" Annual Summary, 1948, published by Weather Bureau, U. S. Department of Commerce

TABLE 3

STREAM FLOW DATA - WASHITA RIVER BASIN

Stream	Gaging Station	Years of Record	Drainage Area (sq. mi.)	Elev. of zero on gage (m.s.l.)	Average Discharge (c.f.s.)	Maximum of Record			Minimum of Record		
						Stage (ft.)	Discharge (c.f.s.)	Date	Stage (ft.)	Discharge (c.f.s.)	Date
Washita River	Cheyenne	10	640	1905.98	—	13.5	40,000	May 23, 1941	—	0	Each year except 1942
Washita River	Clinton	13	1990	1467.60	162	28.50	26,900	June 5, 1936	—	0.9	October 5, 1946
Washita River	Carnegie	11	3230	1249.23	324	22.74	12,000	June 14, 1944	—	6.8	November 3, 1939
Washita River	Tabler	8	4760	1022.38	—	29.08	38,000	May 16, 1947	—	26.0	October and November, 1940
Washita River	Pauls Valley	10	5390	856.14	937	30.60	22,000	June 10, 1941	—	24.0	October 3-5, 1939
Washita River	Durwood	20	7310	650.57	1679	44.37	91,300	May 11, 1943	2.77	17.0	August 14, 1934
Barnitz Creek	Arapaho	3	247	1529.12	—	20.8	2,410	April 8, 1947	—	0	—
Pond Creek	Ft. Cobb	8	320	1252.57	—	17.58	16,000	June 11, 1945	—	4.4	August 3, 1943
Rush Creek	Purdy	8	139	989.70	—	26.1	15,300	May 10, 1943	—	0	At times in 1940
Caddo Creek	Ardmore	12	280	709.48	173	28.6	22,300	March 15, 1945	—	0	At times. 1938-1941 and 1943-1948

Source: U. S. Geological Survey - Water Supply Paper No. 1117

TABLE 4

STREAM FLOW DATA - MINIMUM DISCHARGES

WASHITA RIVER BASIN

Stream	Gaging Station	River Mile	Minimum Average Daily Discharge (c.f.s.) for Consecutive Days Indicated							Maximum No. of Consecutive Days with no flow
			Years of Period	1	7	14	30	60	120	180	
Washita River	Cheyenne	570	10	0	0	0	0	0	0	0	237
" "	Clinton	473	13	1.2	1.51	1.76	2.64	3.76	4.99	5.87	0
" "	Carnegie	387	11	6.9	7.03	7.27	9.65	11.6	13.6	15.5	0
" "	Tabler	-	8	26.0	29.6	30.6	35.5	46.8	96.0	130.0	0
" "	Pauls Valley	173	10	24.0	27.4	30.9	34.9	45.3	54.6	63.7	0
" "	Durwood	89	20	17.0	38.6	42.2	56.2	66.0	87.1	99.6	0
Pond Creek	Ft. Cobb	11	8	5.40	5.54	6.14	6.68	7.34	15.1	20.3	0
Rush Creek	Purdy	26	8	0	0	0	0.	0.14	0.71	14.6	34
Caddo Creek	Ardmore	-	12	0	0	0	0	0	0.022	0.94	112

Data from: Quantity, Occurrence, and Quality of Surface and Ground Water - Oklahoma Planning and Resources Board

quality. The streams can be used if impoundments of sufficient size are constructed to assure ample supply during low flow periods.

Table 5 shows the chemical quality of surface waters at selected locations on the Washita River and several tributaries.

TABLE 5

CHEMICAL QUALITY OF SURFACE WATERS

WASHITA RIVER BASIN

Stream	Sampling Station	Years of Record	Total Dissolved Solids P.P.M.			Total Hardness ($CaCO_3$) P.P.M.			Chloride (Cl) P.P.M.			Water Temperature °F	
			Max.	Min.	Wt'd Aver.	Max.	Min.	Wt'd Aver.	Max.	Min.	Wt'd Aver.	Max.	Min.
Washita River	Foss	2	1740	296	-	1360	155	-	48	3	-	95	FP*
	Carnegie	1 (5 samples)	963	196	-	652	143	-	62	6.5	-	-	-
	Tabler	3	1390	221	529	851	127	354	385	5.?	34	88	FP
	Durwood	5	936	140	-	574	114	-	178	9.6	-	85	FP
Pond Creek	Ft. Cobb	2	626	149	414	432	69	285	25	4	73	89	FP
Little Washita River	Minnehah	1 (4 samples)	2420	1720	-	1170	1090	-	695	252	-	-	-
Rush Creek	Purdy	3	1600	242	753	660	182	427	598	36	196	100	FP

Data from: Chemical Character of Surface Waters of Oklahoma (1946-49) by Oklahoma Planning and Resources Board.

*FP - Freezing Point

ECONOMIC DEVELOPMENT

The economic development in the basin has been dependent primarily upon agricultural activities. To a lesser extent oil and gas production activities have been an important part of the basin's economy. Urban communities have developed primarily as a result of a need for merchandising and service activities, minor manufacturing establishments, transportation, utilities, communication, and miscellaneous activities.

Cattle raising became important to the basin's economy soon after the Civil War and has continued to be a major source of agricultural income. The Washita River and tributaries are important water supplies for the cattle industry.

The large variation in the amount of rainfall, the long growing season, and variety of soils make it possible for a diversity of crops to be grown in the basin. These crops include wheat, oats, corn, soy beans, cotton, sorghum, and alfalfa. Parts of the basin are particularly favorable for orchard products and truck farming. Rush Springs has become famous for its watermelons. The western half of the basin lies within the wheat belt. Cotton is grown in the eastern part where there is a long growing season and rainfall is adequate in normal years. Alfalfa is grown on the bottom lands throughout the basin.

Table 6 shows the estimated value of livestock and crop production in the basin in 1950. The data indicate that the value of livestock exceeded the value of crops produced in 15 of the 18 counties comprising the basin area.

The Soil Conservation Service of the U.S. Department of Agriculture is developing the Washita Basin as one of eleven major soil conservation and flood control demonstration projects in the United States. The preservation and development of the agricultural economy is dependent upon flood control and soil improvement practices.

Petroleum and petroleum products have an important place in the economy of the central and eastern portions of the basin. For purposes of this report producing oil fields have been grouped into 13 major fields for discussion of industrial sources of pollution. Figure 1 shows the production in millions of barrels of oil in the five major oil-producing counties for the years 1940 through 1949. Figure 1a shows five other counties which produced a total of 6.8 million barrels of oil in 1949. Figure 2 shows the total production of oil for each of 15 counties in the basin for the years 1940 through 1949.

Employment figures for 1940 show that 40% of the employed persons were engaged in agriculture; 2.4% were engaged in oil and gas production;

TABLE 6

ESTIMATED VALUE OF LIVESTOCK AND CROP PRODUCTION (1950)
ON FARMS IN WASHITA BASIN

County	Percent of County in Basin	Value of Crops - Produced 1950 (Prorated)	Estimated Value of Live-Stock on Farms 1950 (Prorated)
Beckham	4.6	364,000	175,000
Bryan	8.8	282,000	427,000
Caddo	78.7	1,802,000	5,350,000
Carter	55.6	417,000	2,350,000
Comanche	3.0	80,000	122,800
Custer	71.4	3,835,000	3,817,000
Dewey	6.2	162,300	262,000
Garvin	94.8	2,475,000	4,640,000
Grady	75.7	3,200,000	4,975,000
Johnston	62.5	556,000	2,380,000
Kiowa	34.6	2,980,000	1,610,000
McClain	41.0	838,000	1,322,000
Marshall	45.8	396,000	1,056,000
Murray	98.7	311,800	5,250,000
Pontotoc	1.2	8,630	52,000
Roger Mills	69.2	1,465,000	3,645,000
Stephens	37.4	566,000	1,632,000
Washita	72.3	950,000	4,100,000

Oklahoma Crop and Livestock Reporting Service,
U. S. Department of Agriculture, Oklahoma State Board of Agriculture

Figure 1

BARRELS OF OIL TRANSPORTED BY PIPE LINE

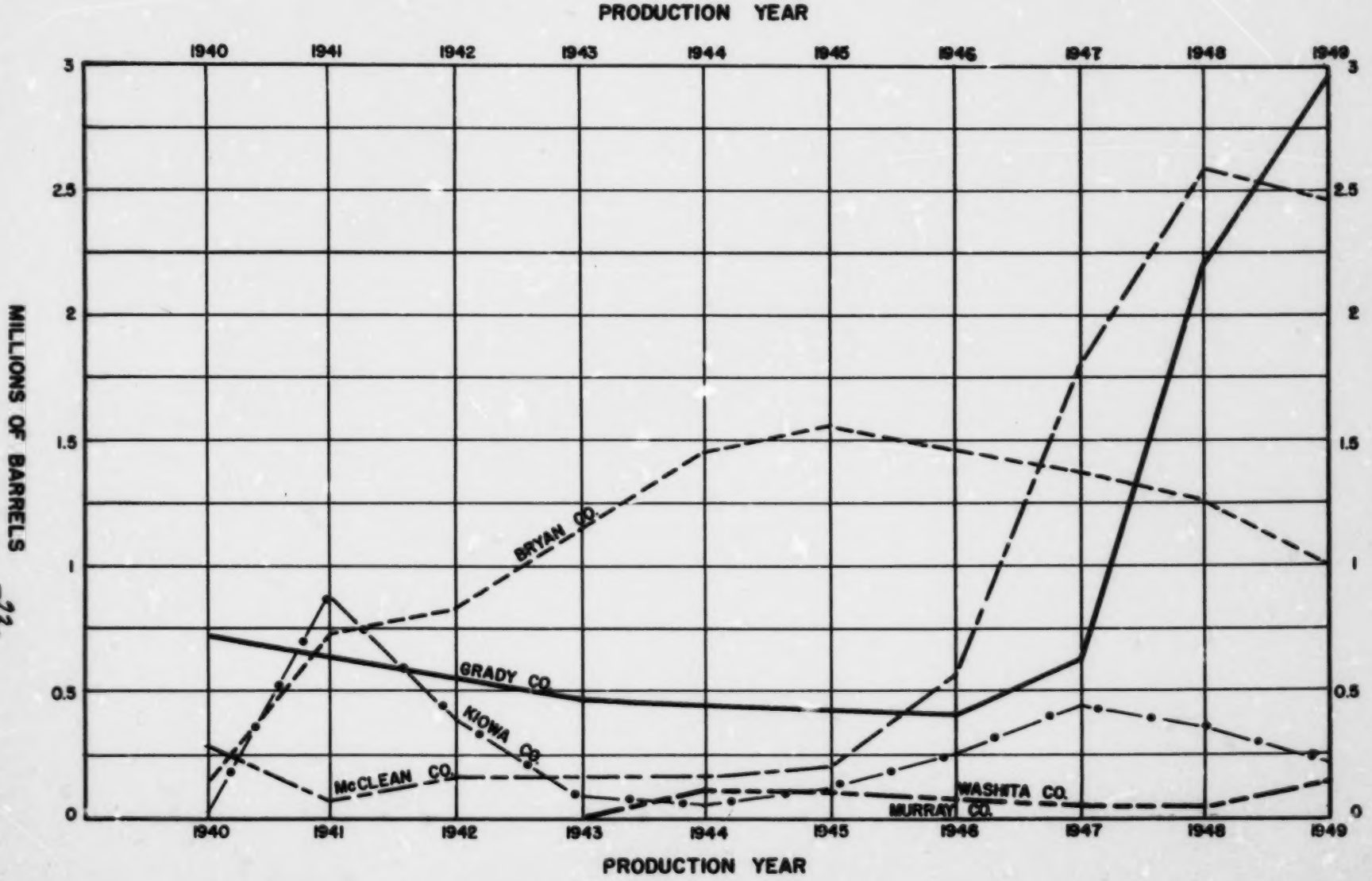


Figure 1 A

BARRELS OF OIL TRANSPORTED BY PIPE LINE

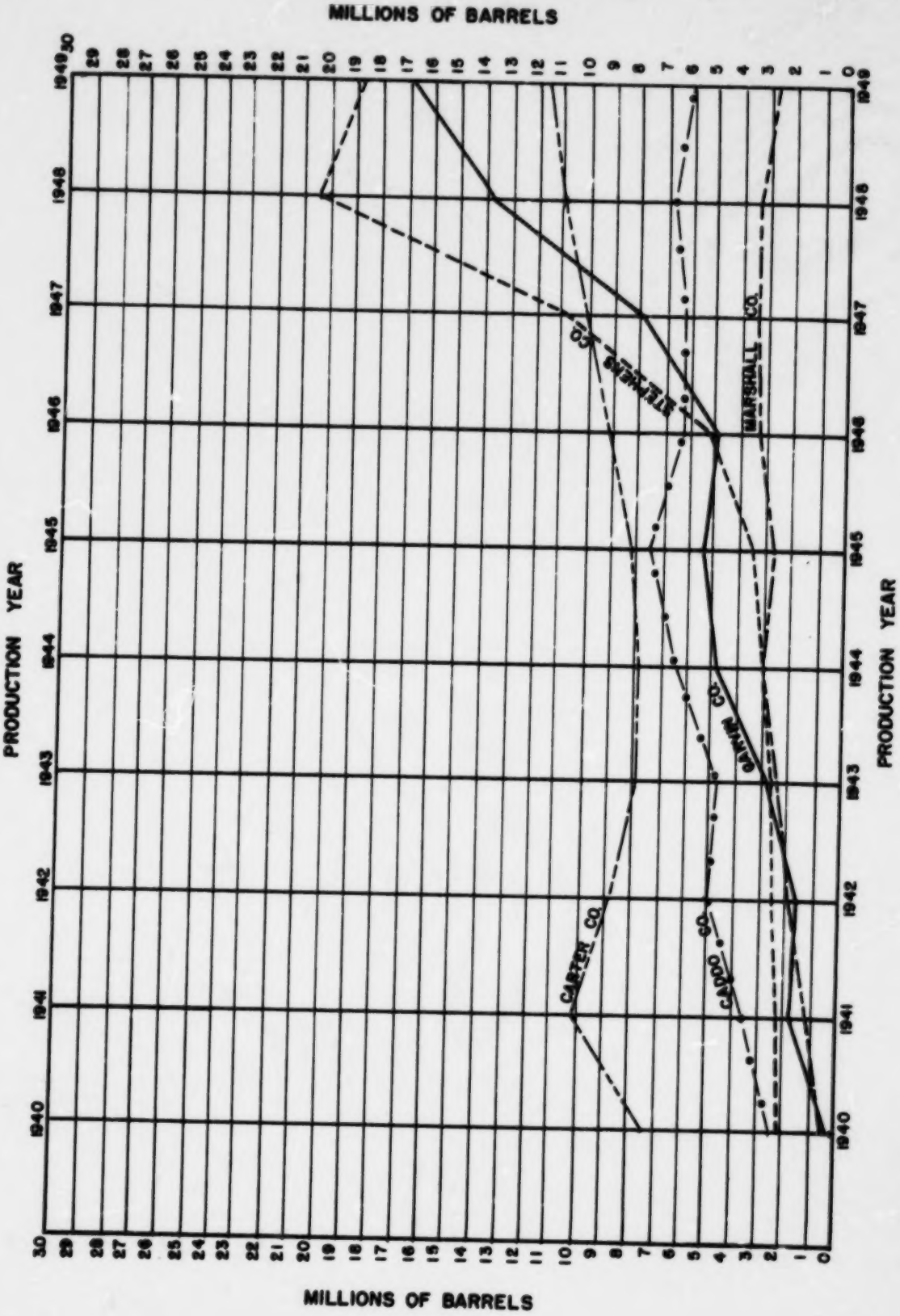
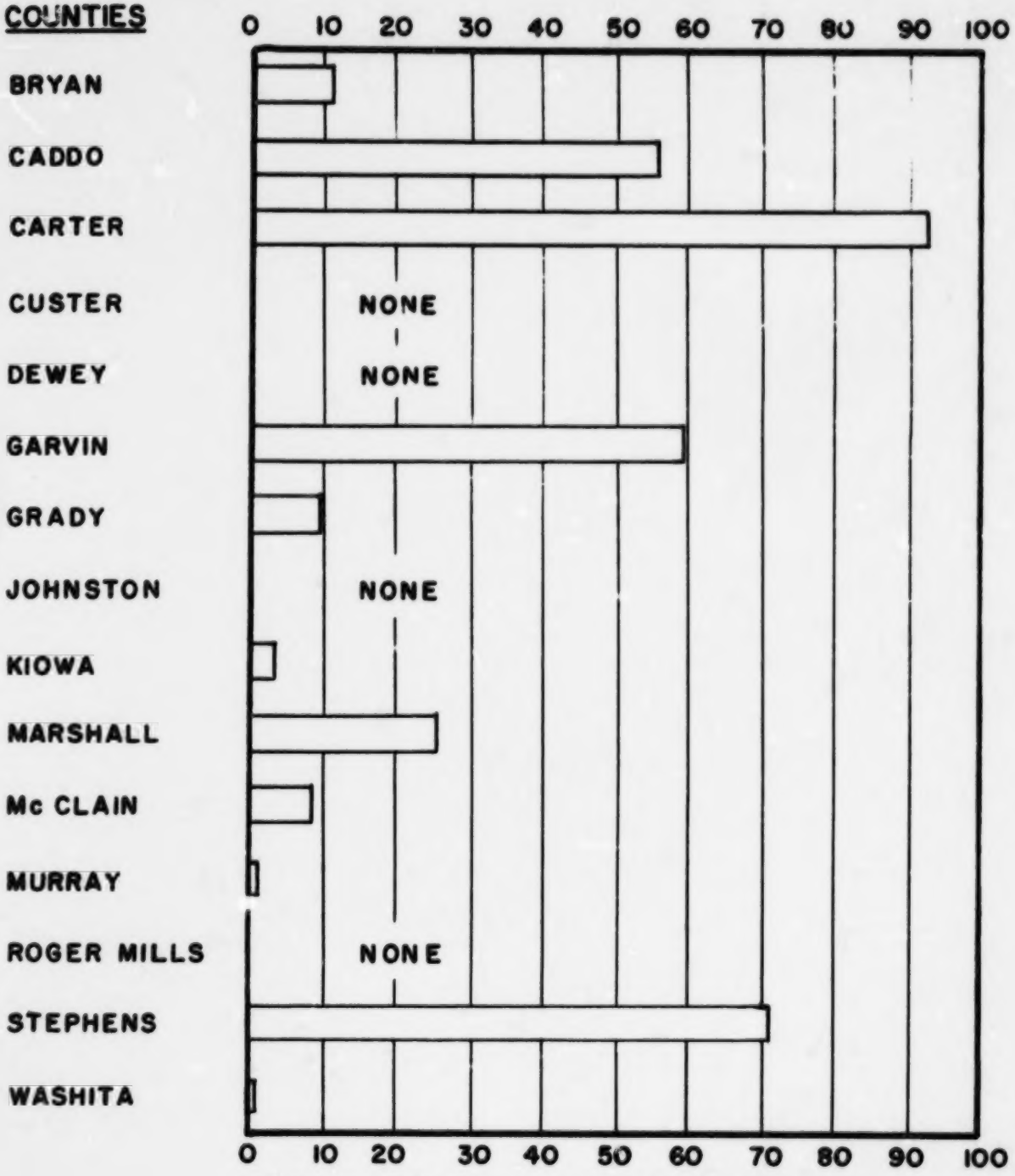


Figure 2

OIL TRANSPORTED BY PIPE LINES (1940-49)

Counties in Washita River Basin



and 30% were engaged in trade and service activities. Transportation, utilities, communication, and miscellaneous activities accounted for the remaining 27.6% of employment. In recent years the number of workers employed in manufacturing, oil and gas production and refining, has increased and the number of agricultural workers has declined.

Table 7 shows the total income and per capita income in 15 counties of the basin and for the state as a whole. Two counties exceed the state average per capita income and seven counties have per capita incomes greater than 75% of the state average.

The population data of 1940 showed that 78% of the population was rural and 22% urban. The basin supported its largest population in 1930. Present estimates are far below the 1930 figure. Reasons for the decline include the drought years of the thirties, when large numbers of rural inhabitants migrated to other states, opportunity for higher wages in industrial centers, the loss of soil fertility, and greater mechanization of farming operations requiring less manpower. Data showing the population trends since 1910 are shown below.

Year	Population
1910	180,000
1930	230,000
1940	210,000
1943	170,000 (ration book census)
1950	172,000

The future economic development of the basin will depend largely on agricultural activity and development of natural resources. Water supply is one of the important natural resources which must be protected and conserved to promote and encourage development of the basin's economy.

TABLE 7

TOTAL INCOME DATA (1949)
WASHITA RIVER BASIN*

County	Population	Total Income	Per Capita Income
Bryan	28,999	$16,789,396	$ 580
Caddo	34,913	27,014,718	775
Carter	36,455	38,855,179	1,069
Custer	21,097	21,001,203	997
Dewey	8,789	7,042,355	802
Garvin	29,500	27,832,901	946
Grady	34,872	27,914,759	803
Johnston	10,608	5,019,902	474
Kiowa	18,926	16,691,256	883
Marshall	8,177	6,000,641	736
McClain	14,681	8,967,765	614
Murray	10,775	6,861,098	639
Roger Mills	7,395	6,455,555	871
Stephens	34,071	38,236,377	1,126
Washita	17,657	17,418,470	991
BASIN TOTAL	316,915	272,101,575	$ 820
STATE TOTAL	2,233,351	2,385,000,000	$1,068

*Beckham, Comanche, and Pontotoc Counties, each with less than 5 percent of area in the basin, are not included.

Source: Bureau of Business Research, University of Oklahoma.

USE OF WATER RESOURCES

The Washita River and its tributaries is considered one of the most important stream systems in the State of Oklahoma. Water uses include municipal and industrial water supplies; agriculture, including livestock watering and irrigation; recreation; fish and wildlife; and final waste disposal. Map No. 1 shows the existing primary water uses of the principal watercourses in the basin.

The quality of the water in the main stem of the Washita River and many of its tributaries is seriously impaired, principally from natural pollution, and, to a lesser extent, from municipal and industrial wastes. The natural pollution consists of excessive mineralization, which is aggravated because of the prolonged low flows occurring in the streams. In addition, heavy sediment loads carried in the streams during above average flow conditions present many problems affecting normal water uses. The quality of water in some sections of the streams is also affected by wastes from municipalities, oil fields, and oil refineries.

Municipal and Industrial Water Supplies

Table 8 is a list of municipal water supplies in the Washita River Basin. Seven municipalities derive all or most of their water supplies from surface sources, and 28 municipalities use wells. These municipal water supplies serve a population of 108,750 persons and numerous small industries. Two cities, Chickasha (population - 15,842) and Anadarko (population - 6,184) obtain water from the Washita River. Two communities, Clinton (7,545) and Madill (2,791), obtain water from impoundments on tributaries of the Washita. Cordell (2,920) uses a surface source and wells. The surface water is taken from a reservoir on a tributary of the Washita. Ardmore (17,890) and Duncan (15,325), although located outside the drainage basin, use impoundments on tributaries of the Washita River for their sources of water supply. In addition to the surface supply, Duncan has auxiliary wells. The seven municipalities mentioned use surface sources to serve about 70,000 persons, which represents 65 percent of the total number of people served by municipal water supplies in the basin.

The water taken from the unregulated flow of the Washita River by Chickasha and Anadarko is inadequate from the standpoint of quality and quantity. Although the water is of inferior quality due to excessive mineralization, sediment, bacterial pollution, and taste- and odor-producing substances, it is the only source presently available. Tributaries having water of better quality are used for sources of public water supplies by several other communities.

The quantity of water in the river during periods of low flows is not adequate to serve present municipal water needs. Anadarko and Chickasha

WASHITA RIVER BASIN

EXISTING PRIMARY WATER USES

FEDERAL SECURITY AGENCY
Public Health Service

TABLE 8

MUNICIPAL WATER SUPPLIES - WASHITA RIVER BASIN

Municipality	1950 Population	Population Served	Sources of Supply	Treatment*	Total Pumpage (Gals)	Consumption G/C/D
Alex	563	550	Wells	None	60,000	109
Anadarko[1]	6,184	6,290	Washita River	PD	640,000	102
Arapahoe	311	311	Well	None	30,000	97
Ardmore[2]	17,890	18,000	Impoundment	PD	1,500,000	83
Bessie	205	200	Well	None	26,000	130
Binger	773	655	Well	D	30,000	46
Butler	351	351	Well	None	30,000	86
Carnegie	1,719	1,700	Well	None	153,000	90
Cement	1,076	900	Well	None	36,000	40
Cheyenne	1,134	1,100	Wells	D	36,000	33
Chickasha	15,842	15,000	Washita River	PD	2,000,000	133
Clinton[3]	7,555	8,400	Lake Clinton	PD	1,500,000	179
Cordell	2,920	3,000	Impoundment	PD	600,000	200
Cyril	998	998	Wells	None	100,000	100
Davis	1,928	1,940	Well	None	200,000	103
Duncan[2]	15,325	16,500	Imp. and well	PD	1,000,000	61
Ft. Cobb	665	650	Well	None	55,000	85
Foss	210	250	Wells	D	30,000	120
Gotebo	574	500	Well	None	36,000	72
Gracemont	301	300	Well	None	20,000	67
Hammon	621	600	Well	None	50,000	83
Kingston	677	700	Well	None	35,000	50
Leedy	588	600	Wells	None	25,000	42
Lindsay	3,021	3,500	Wells	None	300,000	86
Medill	2,790	2,790	Imp. (Mill Creek)	D	235,000	84

TABLE 8 (Cont.)

MUNICIPAL WATER SUPPLIES - WASHITA RIVER BASIN

Municipality	1950 Population	Population Served	Sources of Supply	Treatment*	Total Pumpage (Gals)	Consumption G/C/D
Marlow	3,399	3,000	Well	None	500,000	167
Maysville	1,294	1,160	Well	None	85,000	73
Mountain View	1,009	900	Well	D	75,000	83
Pauls Valley	6,896	6,700	Wells	D	650,000	97
Paoli	353	250	Well	None	5,000	20
Rush Springs	1,402	1,200	Well	None	180,000	150
Sulphur	4,389	4,500	Well	None	650,000	144
Tishomingo	2,325	2,350	Spring	D	300,000	128
Verden	508	500	Well	None	24,000	48
Wynnewood	2,423	2,400	Wells	D	200,000	83

*Treatment Code

P - purification
D - disinfection

[1]Serves Riverside Indian School
[2]Municipalities outside basin with supply in basin
[3]Serves Western T. B. Hospital

experience critical water shortages during extended dry periods. Clinton, which takes water from an impoundment on Turkey Creek, is also confronted with a problem involving its source of supply, which has been greatly reduced as a result of deposition of silt in the reservoir.

The industrial water supplies are used principally for the processing of petroleum and gas. Petroleum refineries at Cyril and Wynnewood and numerous gasoline plants use water from company-owned wells. Data available indicates that the water used by two refineries and three gasoline plants amounts to approximately 1.5 million gallons per day. Data regarding water use for the majority of gasoline plants, however, are not available; but it is estimated that these plants with private well supplies require an additional two million gallons per day.

Three railroads use approximately 130,000 gallons of water per day from surface sources on Rock Creek, Mill Creek, and Wildhorse Creek. Private well supplies are used by two railroads at Pauls Valley and Chickasha, and two railroads use the public supplies at Madill and Cyril. The total water consumption by railroads amounts to slightly more than one-fourth million gallons per day.

A variety of small industries, including cotton ginning and cotton seed oil extraction, poultry and produce packing, dairy products, ice plants, bottling works, building materials, metal and machine shops, and some railroads use municipal water supplies. The quantity of water used by these industries is reflected in the municipal water consumption data included in Table 8.

Favorable agricultural and industrial opportunities in the Washita Basin should produce greater stimulation in community growth and industrial development than has occurred in the past. One of the reasons advanced for this lag in growth, especially in the cities of Anadarko and Chickasha, is the unsuitable quality and limited quantity of water supplies available. It is recognized by the State and local interests that adequate supplies of water of suitable quality are urgently needed to stimulate municipal and industrial growth in the basin.

Agriculture

Agricultural uses of water in the basin are principally for livestock watering and irrigation. The surface waters throughout the basin are used for this purpose. The importance of livestock water may be appreciated from a review of Table 6 which shows that the value of livestock raised in the 15 counties comprising most of the basin area amounts to an appreciable portion of the total agricultural income.

Irrigation by surface water is practiced mainly in the lower portion of the basin and ground water is utilized in the upper portion where the surface

supplies are limited and unreliable.

Table 9 summarizes the data pertaining to applications for irrigation water rights in the Washita Basin granted by the Oklahoma Planning and Resources Board. One hundred and forty-two applications have been granted for irrigation water since 1933. Seventh-one applications for water rights were approved in 1939-1940 to irrigate 5,700 acres of land. From 1947 to July, 1951, water rights were granted to 55 individuals for irrigation of 7,900 acres. The principal crops irrigated are cotton, alfalfa, and sorghum and minor acreages are planted in vegetables and specialty crops. In the extreme western portion of the basin undependable water flows during prolonged dry periods limit the practice of irrigation when irrigation needs are the greatest.

Fish and Wildlife

The Washita and tributaries are used for game fishing throughout the basin except for some of the headwater sections where streams are intermittent. Catfish, carp, buffalo, freshwater drum, bullheads, and several of the sunfishes are commonly caught. A few largemouth bass are found in some of the side drainages along the streams. Forty-seven commercial fishing licenses have been issued to residents in nine of the 15 counties that comprise most of the basin. Most of the commercial fishing is confined to Lake Texoma, though some is practiced in the Washita River as far upstream as Anadarko.

Upland game and fur animals are important wildlife resources and are fairly well distributed in the basin. Some of the best quail hunting in Oklahoma exists near Fort Cobb and Lindsay. Lake Texoma provides a suitable environment for waterfowl, and quite a number of deer inhabit the areas near the lake.

The Denison Dam, completed in 1944 by the Corps of Engineers, was designed primarily for flood control and hydroelectric power. It is located on the Red River eight miles below the confluence of the Washita and Red Rivers. As the result of this project, water is impounded in the Washita Valley for a distance of 80 miles. Although many acres of valuable land have been covered by water, the lake is an important multiple purpose reservoir and is beneficial to the valuable fishing and recreational resources. Reservoirs near Clinton, Cordell, Ardmore, Duncan, Madill, and Tishomingo, though constructed primarily for municipal water supplies, also afford fishing and recreational opportunities.

Recreation

Game fishing, which is available in most of the streams and Lake Texoma, is an important recreational activity in the basin. Hunting is also of importance throughout the upland areas. Other recreational activities,

TABLE 9

APPLICATIONS FOR WATER RIGHTS (1933 - 1951)
WASHITA RIVER BASIN

County	Purpose	No. of Projects	No. of Acres to be Irrigated
Beckham	Conservation and flood control	3	
	Flood control	6	
Caddo	Municipal, Domestic, Commercial and Industrial	1	
	Irrigation	31	3033
	Irrigation	6	Unknown
	Industrial	1	
Carter	Flood control	1	
	Domestic and Industrial	1	15
	Irrigation	1	
Custer	Conservation and flood control	1	
	Flood control	1	
	Irrigation	15	1360
	Irrigation	2	Unknown
Garvin	Irrigation and flood control	1	10
	Irrigation and flood control	1	Unknown
	Irrigation	7	1507
	Irrigation	3	Unknown
Grady	Municipal	1	
	Conservation and flood control	1	
	Irrigation	49	5789
	Irrigation	5	Unknown
Kiowa	Irrigation	1	118
	Irrigation	1	Unknown
McClain	Conservation, flood control and stock watering	4	
Murray	Domestic and Recreational	1	
	Industrial	1	
	Irrigation	6	1750
Roger Mills	Conservation and flood control	5	
	Flood control	3	
	Irrigation	7	404
Stephens	Municipal	1	
	Conservation and flood control	4	
	Irrigation	1	65
Washita	Conservation and flood control	1	-
	Irrigation	4	256
	Irrigation	1	Unknown
	TOTAL	179	
	Non-irrigation	37	
	Irrigation	142	

including boating and bathing, are confined to Lake Texoma. More than two million persons visit the lake annually.

The State Game and Fish Commission is active in the development of sport fishing by stocking numerous farm ponds spotted throughout the basin. With the exception of the Lake Texoma area and a few local developments, the present recreational resources have not been appreciably developed for the convenience and welfare of the local inhabitants.

Fish and wildlife interests recognize the need for facilities to assure the protection and propagation of fish and wildlife resources to develop the recreational opportunities afforded by these resources. There is also a further need for other recreational facilities, including boating, bathing, and park areas for picnicking and camping.

Waste Disposal

At the present time, oil field and refinery wastes are the major sources of pollution reaching the watercourses. Municipal wastes affecting water uses also present problems in several local areas. It is recognized that some portion of the surface waters must be used for the final disposal of municipal and industrial wastes treatment effluents. The use of the watercourses for this purpose, however, is too often exploited and continues uncontrolled at the expense of more important primary water uses. The use of waters of the river system should allow for reasonable final waste disposal, but this use should yield through adequate control to the primary water uses. All water uses will benefit if judicious use of the watercourses is made for final disposal of municipal and industrial wastes.

POLLUTION CONTRIBUTED TO WATER RESOURCES

Pollution contributed to the Washita River and its tributaries consists of municipal sewage, oil field brines and refinery wastes, and natural pollution, such as dissolved minerals and sediment.

Table A summarizes the data available on municipal sources of pollution. The 30 sources of pollution listed include three institutions and two communities without existing sewage collection systems. The two communities, however, are planning to install collection and treatment facilities in the near future. Seven additional communities, each of less than 500 population, that have public water supplies but no existing sewage collection systems, are not considered as sources of pollution for purposes of this report.

Twenty-eight municipalities, including three institutions, serve a combined sewered population of 60,800. Two municipalities without existing sewer systems have a total census population of 1600. The total pollution load discharged to water courses from the sewered municipalities is equivalent to the untreated sewage from 29,200 persons (population equivalent). Existing municipal waste treatment plants reduce the original pollution load produced by these sources by about 50 percent.

The cities of Anadarko and Pauls Valley are now discharging raw sewage into the Washita River. Both of these cities have sewage treatment plants under construction.

The Western T. B. Hospital, near Clinton, discharges the effluent from its secondary type treatment plant into the upper reach of the Washita River. Although secondary treatment of the wastes is provided, the facilities are considered inadequate from the standpoint of capacity and operation, and chlorination of the effluent is recommended to reduce the public health hazard associated with this type of waste.

Map No. 2 shows the sources of municipal pollution and existing treatment facilities in the basin.

Industrial pollution originates principally from the petroleum production and processing activities. Other industries found in the basin discharge their wastes into municipal sewer systems or are of relatively minor significance from a pollution standpoint. Map No. 3 shows the sources of industrial pollution and existing treatment facilities in the basin.

Table B summarizes the sources of industrial waste pollution. The petroleum and gas producing wells have been grouped into 13 major fields to facilitate discussion of the pollution problems resulting from this industry. Pollution from these sources is due mainly to brines, though in some cases crude oil reaches the watercourses as a result of incomplete separation of

TABLE A

SOURCES OF POLLUTION

MUNICIPAL

Municipalities*	Sources of Pollution (In Number of Municipalities*)	Population Served by Sewerage System	Amount of Pollution Discharged to Watercourse (In Terms of Equivalent Number of People)**
Having data on pollution load discharged to watercourse	28	60,800	29,200
Having population data available (Data on pollution load to watercourse incomplete or not available)	2 1/	1,600	Not applicable
TOTAL	30	62,400	29,200

*Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers or other population centers.

**Includes industrial wastes discharged into municipal sewerage systems.

1/Communities with no existing sewerage systems; new systems in active planning stage.

TABLE B

SOURCES OF POLLUTION

INDUSTRIAL

Industries*	Sources of Pollution (In Number of Plants)	Amount of Pollution Discharged to Watercourse (In Terms of Equivalent Number of People)
Producing Organic Wastes	0	—
Producing Organic Wastes	2	Undetermined
Producing Inorganic Wastes	15 1/	Not applicable
Producing Wastes of Undetermined Type	0	Undetermined
TOTAL	15 2/	xxxxx

*Industries having separate outlets discharging wastes directly to watercourse.

1/Includes two refineries also producing organic wastes.

2/Total adjusted to correct for duplication noted in footnote marked thus, 1/

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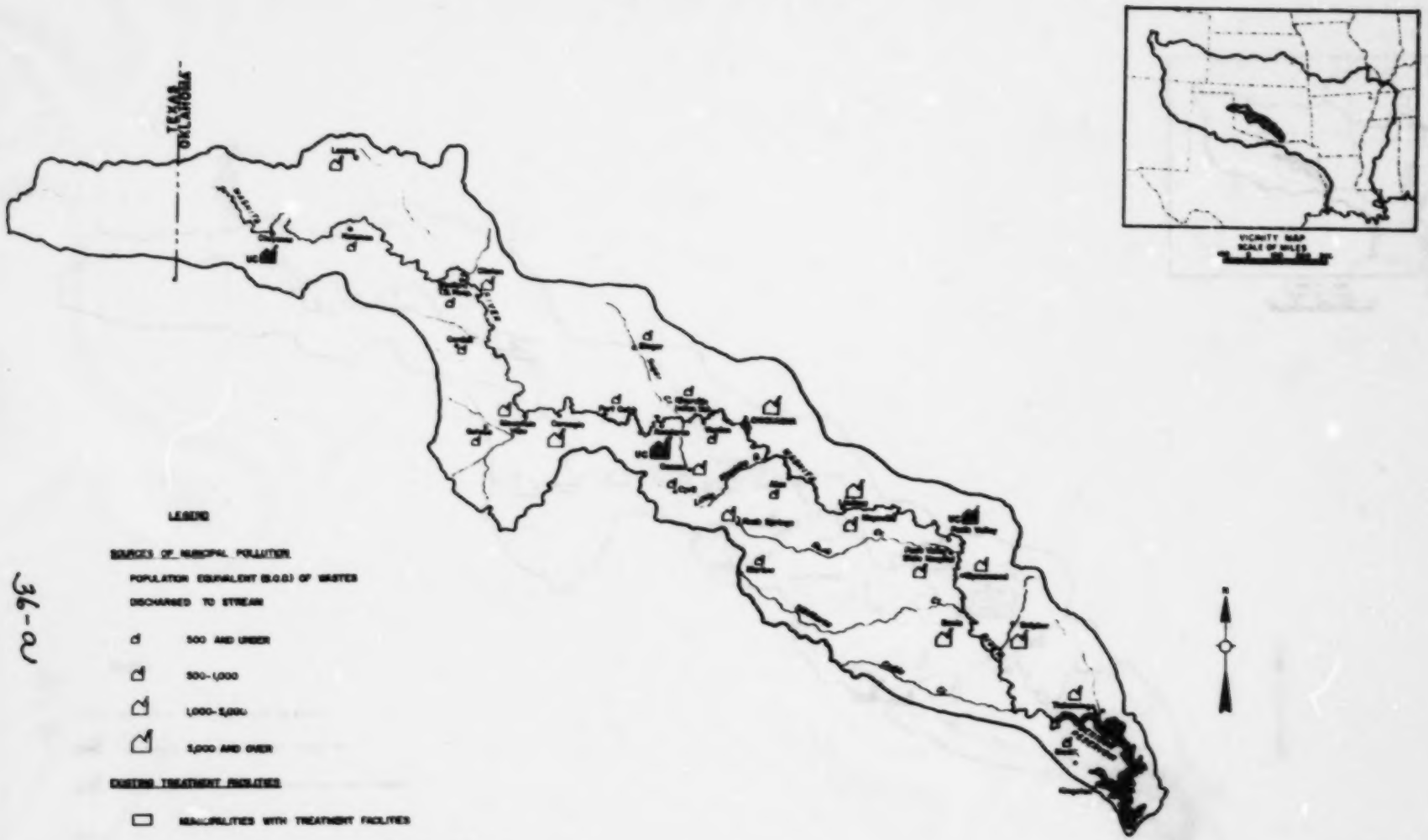

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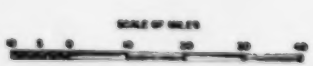
WASHITA RIVER BASIN

SOURCES OF MUNICIPAL POLLUTION AND EXISTING TREATMENT FACILITIES

FEDERAL SECURITY AGENCY
Public Health Service
Division of Water Pollution Control
Map No. 2



WASHITA RIVER BASIN

SOURCES OF INDUSTRIAL POLLUTION
AND
EXISTING TREATMENT FACILITIES

FEDERAL SECURITY AGENCY
Public Health Service
Division of Water Pollution Control
Map No. 2

oil from the brines, or as a result of leaks and spills. The pollution load resulting from the predominantly inorganic type wastes cannot be represented in terms of a population equivalent. Two oil refineries produce wastes of both organic and inorganic type. The pollution load discharged by the refineries is undetermined.

A number of gasoline plants located within the basin are not included as sources of pollution because little, if any, wastes are discharged from these plants. The extent to which oil field wastes are affecting the water quality in the Washita River and some of its tributaries is reflected by the high chloride concentration data shown in Table 5.

Pollution from natural sources includes dissolved minerals and sediment from soil erosion. The waters of the main stem of the Washita River and some of the tributaries are highly mineralized from contact with extensive mineral deposits, especially gypsum, along their courses. Excessive hardness imparted to the waters by the minerals is an ever present problem facing water supply treatment for municipal and industrial uses.

Local high intensity rainfall of erratic occurrence causes extensive scouring of the cultivated lands and carries large volumes of sediment into the Washita River by way of its numerous tributaries. Detailed sedimentation surveys by the Corps of Engineers show that the average annual accumulation of sediment in the Washita arm of Lake Texoma is 1.29 acre-feet per square mile as compared with 0.78 acre-feet per square mile for the entire reservoir. The high rate of sedimentation in the Washita arm indicates higher erosion rates in the Washita Basin than in the upper Red River drainage area.

The sediment carried by streams, even during average flows, affects all normal water uses and especially agricultural, municipal, and industrial water supplies and fish and other aquatic life.

DAMAGES TO WATER RESOURCES FROM POLLUTION

All primary water uses in the Washita River Basin are affected to some degree by pollution originating from municipal sewage, petroleum production and refining wastes, natural dissolved minerals, and sediment. Damages to the water resources from pollution may be considered under two general categories, namely, the existing or specific damages, and the potential damages which may result from the use of polluted waters.

Municipal water supplies obtained from polluted surface waters require more extensive treatment processes and facilities to provide potable water for domestic purposes. Some municipalities along the Washita River resort to well water supplies or impoundments on tributaries because of the inferior quality and associated high cost of treating Washita River water.

Anadarko and Chickasha use the Washita River as the source of their public supplies. Chickasha, by virtue of its location downstream from Anadarko, has been subjected to pollution of its raw water supply from the discharge of untreated municipal wastes from Anadarko. Bacterial pollution originating from the raw sewage and taste and odor-producing substances present in the raw water supply of Chickasha have been a public health hazard and continual source of concern of the officials of that city and the State Department of Health.

In addition to the municipal wastes which affect the quality of the river water locally, more extensive damage to the waters results from the discharge of wastes from petroleum production operations, excessive mineralization, and sediment. The petroleum wastes are considered the cause, in part at least, of the taste and odor troubles in the water supplies; and the dissolved minerals, especially gypsum, imparts excessive hardness which makes softening imperative for most domestic and industrial uses.

This situation has forced Chickasha to investigate other sources of water supply, and the city is presently preparing plans for the development of a supply on a tributary stream. The pollution problem resulting from municipal wastes will be greatly alleviated, however, when a complete sewage treatment plant is completed at Anadarko and placed in operation in the near future.

Sediment damage to several water supply reservoirs, especially at Clinton, is of serious importance. The rapid rate of sediment deposition in these impoundments, resulting in loss of useful capacity, will not only impose a financial burden on the communities for the development of new reservoirs, but is particularly significant since additional favorable sites are not abundant.

Limited water use for industrial purposes is mainly from ground water

sources. The present sources yield sufficient volume to support the degree of development attained thus far, but there is no assurance that any substantial future expansion of industrial use can be supported by presently utilized ground water resources. Further, the hardness and other mineral content of ground waters throughout the major portion of the basin is so high as to render them generally unsuitable for many domestic and industrial uses without costly treatment. It is a well-established opinion that municipal and industrial development has not occurred commensurate with favorable factors in the basin largely because of the inferior quality and quantity of the available water resources.

Floods cause considerable damage to agriculture in the basin. In addition to the destructive floodwater damage to crops and facilities, the damages by sediment deposition on farm lands and reservoir storage is a serious problem in a major portion of the basin. It is reported that approximately 265,000 acres of valley land have been damaged by sediment deposition, scouring, and stream-bank erosion. The monetary value of damages by sediment as estimated by the U.S. Department of Agriculture amounts to $330,000 annually. In addition to the land damage, deposition of sediment has reduced channel capacities, thereby impairing drainage and increasing the frequency of flooding.

Although limited use is made of surface waters for irrigation, except in Grady, Murray, and Carter Counties, the use of sewage-polluted waters for irrigation of truck crops presents a potential public health hazard. This problem will become proportionately greater if water and land resources developments are instituted in the basin and irrigated acreage is greatly expanded.

The use of polluted waters for livestock watering purposes must receive consideration in the basin. Oil and oil brine pollution reaching the watercourses used for livestock water presents a potential economic loss to the important stock-raising enterprises which contribute a large share to the economy of the region. Several cases of actual livestock destruction are on record, and it is known generally that the feeding habits of cattle exposed to brine-polluted waters are seriously affected and their natural development is impaired.

Damages to the fish resources of the basin are real, as evidenced by the numerous legal prosecutions conducted by the Oklahoma Game and Fish Department. Several petroleum-producing companies have been fined for polluting Rush Creek in Grady County, Wildhorse Creek in Stephens County, and Burbank Creek in Garvin County, and causing destruction of fish by the discharge of brines and oil to the streams. The discharge of these wastes, which are toxic to other aquatic life, also causes indirect damage to the fish population by destroying the plant and animal life which is used as a source of fish food. The deposition of sediment in the streams similarly hinders the propagation of fish by covering the sources of food supply and

spawning grounds.

Water recreational opportunities, other than fishing, are little affected by pollution solely because of their present limited importance. The presence of pollution, however, hampers the development of recreational facilities near centers of population where the conveniences could be enjoyed by many.

BENEFITS RESULTING FROM POLLUTION PREVENTION AND ABATEMENT

In the consideration of benefits resulting from pollution prevention and abatement it can be stated generally that all legitimate water uses enjoy some degree of benefit, either directly or indirectly. In a broader sense, the benefits may be applied to many aspects of conservation and development of our fundamental human, land, and water resources. In some cases the benefits can be evaluated on a monetary basis and are considered as tangible benefits. In this category are included principally the direct benefits occurring to municipal and industrial water supplies from reduced costs of water treatment or from savings in capital expenditures required for development of supplies. Of equal or greater importance and most generally prevailing, however, are the intangible benefits to public health, recreation, aquatic life, property values, and purely aesthetic considerations, which are equally real and justified, but because of their nature cannot readily be assigned a specific or monetary value.

The larger towns and cities in the Washita River Basin have developed surface water supplies, mainly because ground water resources are inadequate in volume, and in some cases because the quality of the surface water is relatively better than that of available ground water. Two of these cities, Anadarko and Chickasha, which derive their supplies from the unregulated flow of the Washita River, are faced with recurring water supply problems involving both quantity and quality. In the past these communities were forced to meet the problems with undesirable stop-gap measures.

The benefit to water supplies in the Washita River Basin will result, therefore, from increased stream flows provided by water conservation projects and by flow regulation, as well as pollution abatement. At present, it appears that the most serious pollution problem in the basin affecting the public water supply of Chickasha, will be greatly alleviated in the near future with the completion of the sewage treatment plant at Anadarko located about 30 miles upstream. Pollution abatement may also be regarded as a potential benefit to many smaller communities which, in the future, may have to develop supplies from surface sources if and when ground water supplies become insufficient or undesirable.

Industry has been slow to develop in the basin despite the prevalence of raw materials and other favorable factors. Most of the existing industries obtain water supplies from ground water sources, but in general a better quality water is required for industrial use than is presently available in many areas of the basin. The excessive mineralization which imparts undesirable hardness to the waters, together with the limited and undependable supplies, are considered the causes, in part at least, for the lag in industrial development. Any beneficial changes in the quality and quantity of water resources available for industrial use will decrease the high cost of water

treatment and capital expenditures for development of supplies.

Improvement of water quality and quantity, therefore, can be regarded as a direct financial benefit to industry and also serve as an incentive for industrial expansion and new developments.

Another benefit to industry from pollution abatement often results from the application of waste control measures. Although of limited importance in the basin at present, it has been demonstrated in numerous instances that industrial waste treatment often results in conservation of valuable resources through reuse of salvaged raw material or by-products. The return realized from the reuse or sale of recovered material is in many cases a direct financial benefit to the industry or contributes to the cost of installation and operation of waste treatment facilities.

Agricultural water use will probably be benefited in greatest proportion because of the present and anticipated development of irrigation projects and associated farming activities, including livestock raising. The potential public health hazards associated with the use of sewage-polluted waters for irrigation of many varieties of truck garden crops is definitely reduced by proper treatment of domestic sewage normally carrying disease organisms. The use of "clean" waters also offers the important farming industry a certain degree of protection from damage suits and unfavorable publicity which may result from the use of polluted waters for irrigation.

The protection of water used for livestock watering can result in real benefits by preventing actual livestock losses and by promoting optimum growth and development of animals.

The control of silt pollution will result in multibenefits to agriculture primarily by retaining the valuable soil cover on the land and by reducing siltation of water conservation impoundments and other irrigation facilities.

Although the fish resources in the streams and impoundments cannot be considered as abundant, fishing as a recreational pursuit is important throughout the entire basin; and some commercial fishing is done along the main stem of the Washita River below Anadarko. The propagation of fish and other aquatic life in the upper reaches of the Washita and local tributaries has been hampered mainly by the intermittent character of the stream flows and heavy sediment loads. The control of sediment will permit development of the fish resources which are in great demand by the inhabitants of the basin. In several local areas, abatement of pollution resulting from toxic and other deleterious substances and oxygen-consuming materials discharged from petroleum-processing operations will restore barren streams which are otherwise suitable for propagation of fish and other aquatic life.

In addition to increasing the recreational opportunities by developing the fish resources in the basin through pollution abatement, the improvement

of the aesthetic qualities of the waters offers added inducement for the development of bathing and other recreational facilities for the convenience of many who are presently compelled to seek the facilities in areas outside the basin.

POLLUTION PREVENTION MEASURES IN EFFECT

Considerable progress in initiating and providing pollution prevention measures is in evidence in the basin. The accomplishments are reflected by the relatively large number of sewage treatment plants and oil well brine disposal systems installed throughout the basin. These pollution abatement facilities are effecting a measurable reduction of the amount of pollution originating from municipal sources and from the operations of the oil industry. Soil conservation practices also have been instituted in several areas to alleviate the sediment pollution load carried by the streams.

Data regarding existing municipal waste treatment plants are summarized in Table C and Table 1a in the appendix. Twenty-six of the 30 municipalities reported as sources of pollution in the basin provide for some degree of treatment of their wastes. Comprising the four municipalities listed in Table C as providing no treatment at present are three communities with plants under construction, and one community with no existing sewer system. Kingston has active plans for construction of complete sewer system and treatment plant.

Seventeen municipalities have primary treatment plants serving 16,500 persons or 26 percent of the total sewered population, and nine municipalities have secondary treatment plants serving 33,400 persons or 54 percent of the present sewered population. Plants under construction at Anadarko, Pauls Valley, and Cheyenne will serve an additional 19 percent or nearly 12,000 persons. Only one percent of the present sewered population is not served by some type of treatment works, either in operation or under construction.

Table D and Table 2a in the appendix show the status of waste treatment facilities for the major sources of industrial pollution which is discharged through separate outlets directly into the watercourses. Industries discharging wastes to municipal sewerage systems are not included in the tabulation.

There are 13 known oil and gas production industries which are regarded as sources of pollution in the basin. Nine of these sources have facilities for the control or disposal of wastes, and wastes from the four remaining sources are discharged to the streams without treatment. Two oil refineries operating in the basin do not have waste treatment facilities.

The disposal of wastes produced by the important oil industry is a major problem in the basin. The Planning and Resources Board of Oklahoma became active in a program of pollution abatement for the oil industry in 1937. In general, the wastes from fields developed since that date are adequately disposed of or plans for disposal are in the active stage. The

TABLE C

EXISTING TREATMENT FACILITIES

MUNICIPAL

Degree of Treatment Provided	Number of Municipalities* Served	Number of Treatment Plants	Population Served
Primary	17	17	16,500
Secondary	9	9	33,400
No Treatment	4 1/	-	12,500

*Includes incorporated or unincorporated municipalities, other legal bodies as sanitary districts, counties, towns, significant institutions, resorts, recreational centers, or other population centers.

1/Includes Chickasha, Pauls Valley, and Cheyenne with plants under construction, and Kingston with no existing sewer system.

TABLE D

EXISTING TREATMENT FACILITIES

INDUSTRIAL

Type Industry*	Number of Plants	Number of Industrial Plants Having:		
		Treatment Facilities	No Treatment Facilities	Undetermined Facilities
Oil and gas production	13	9	4	0
Products of petroleum	2	0	2	0

*Industries having separate outlets discharging wastes directly to watercourse.

new fields are developing their waste disposal plans with active assistance of the Planning and Resources Board. Pollution is being reduced in the oil fields developed prior to 1937 also, but abatement programs are difficult to initiate because production of oil in these older fields has fallen to the point where installation of waste disposal systems would wipe out the small margin of profit remaining. This means that few operators are willing to spend money on waste disposal facilities. These older fields are rapidly eliminating themselves, however; and within a relatively short time pollution from most of these fields will not be a problem.

In the Rainy Mountain drainage area, about 70 percent of the brines from the Northeast Hobart field is eliminated by disposal through subsurface injection systems. The remaining brine entering this tributary is highly diluted when it enters the main stem of the Washita River. Eighty-five percent of the brines from the Cement field are disposed of through subsurface disposal wells and the amount leaving the field is negligible. The excess brine, as well as the effluent discharged from the oil refinery at Cyril and wastes from the Chickasha gas field, enters the Little Washita River; and at low flows the chloride content of the stream has been found to average 695 p.p.m.

The North Pauls Valley and East Pauls Valley fields are both completely provided with subsurface disposal systems.

The combination of 11 fields known as the Golden Trend District is a relatively new development. Plans for waste disposal have been completed, and construction is underway for underground disposal of brines for the portion of this field that lies in the Washita Basin.

The Velma and Sholem Alechem fields are under development. No brine wastes are being produced, but plans have been formulated for a salt water disposal association.

About 60 percent of the wastes from the Tatums and Fox fields, which drain into Caddo Creek, are disposed of in subsurface systems. The remainder is impounded in evaporation pits and very little reaches the stream.

The Cumberland field on the Washita River east of Madill is provided with underground disposal systems for all the brine wastes. In the Knox field, located on Rush Creek, about 70 percent of the brine wastes is injected into underground systems; the remainder is put into evaporation pits.

The Robberson field on Wildhorse Creek is a very old field, and the wells are down to the "stripper" stage. Approximately one-half of the wastes is being returned to underground formations.

The Corporation Commission of the State of Oklahoma is responsible for issuing permits to drill oil and gas wells in the state and licensing of the companies engaged in plugging abandoned wells to prevent reinjected salt water

from damaging the fresh water strata. The Commission is also responsible for establishing the requirements for surface casing in oil wells. All of these operations are a very important part of pollution control, since the most serious industrial pollution in the basin is from the oil production industry.

The administration and enforcement of existing state anti-pollution laws is an important factor helping prevent pollution of the watercourses. A digest of Oklahoma water pollution control legislation is included in the appendix of this report.

Authority and responsibility for water pollution prevention and abatement is divided among the following state agencies: (1)State Department of Health, (2)Planning and Resources Board, (3)Corporation Commission, and (4)Game and Fish Department. The Oklahoma Game and Fish Department, primarily, has been active in enforcing existing water pollution laws as affecting its interests and responsibilities. Records of prosecutions, involving industries and individuals, during the two-year period ending July, 1949, show that 245 cases brought fines up to $500.00 per violation. These cases mainly involved industrial waste pollution of streams resulting in damage to the fish and wildlife resources of the state.

The important problem of sediment control is being attacked by the cooperative efforts of the farmers and landowners, and the local, state, and Federal governments. Through local organizations of soil conservation districts, cooperating with the Soil Conservation Service, U. S. Department of Agriculture, sediment control programs have been initiated in many areas. Recognizing that sediment control begins with erosion control, the measures applied involved land management practices such as contouring, terracing, crop rotation, and pasture management. These practices are aimed at preventing or retarding runoff, thereby retaining the soil and maintaining the fertility of the lands. The Washita Basin is one of eleven demonstration areas in the United States where the soil conservation practices are being supplemented by the construction of small flood control structures at the headwaters of the tributary streams.

The State Department of Health is delegated authority and responsibility, by statutes relating to water pollution, to deal with all matters pertaining to public water supplies and sewage treatment facilities as affecting or related to public health.

Program activities of the State Department of Health primarily have been responsible for installation of the many municipal sewage treatment plants in the basin. In addition to determining the need for treatment facilities, recommending construction of needed projects, and rendering plan approval services, the Department concerns itself with surveillance over operation of existing plants.

For the purpose of obtaining basic data to aid in determining pollution abatement needs in the basin, the Department has conducted studies of municipal sewage disposal problems by use of its mobile laboratory unit and staff. These studies were made at the request of city officials, and the data were used to gage the efficiency of existing treatment facilities or to assist the cities by providing information necessary for the design of new plants or additions and enlargements to existing plants. The results of studies at seven municipalities are summarized in Table 10.

The number of existing municipal and industrial waste treatment facilities, however, does not necessarily represent a measure of the pollution abated from the watercourses in the basin. The effectiveness of any type of facility is measured by the net result in accomplishing reduction of pollution discharged to the receiving stream.

A large percentage of the existing municipal waste treatment plants have either become obsolete or inadequate for reasons of insufficient capacity, poor maintenance, or neglected operation. The adequacy of existing municipal treatment facilities, with relation to capacity and operation, is shown in Table E. Only three plants, or about 11 percent, are adequate as to capacity; and the operation of six plants, or 23 percent, is regarded as satisfactory.

Table F shows the adequacy of existing industrial waste treatment facilities. Of the nine oil well brine disposal systems reported, three are adequate as to capacity; and the operation of all nine systems is considered satisfactory.

Gradual continued progress in construction of municipal pollution abatement facilities is in evidence in the basin. The number of plants built in the last five-year period (1947-51 inclusive) is shown in Table G. Three of the four plants listed were reported as under construction as of December 1, 1951. Information regarding industrial waste treatment facilities constructed during the period is not available.

To achieve pollution abatement through the construction of necessary facifacilities, it is important that the efficiency of any waste treatment plant be maintained by providing proper maintenance and operation of the works. The Oklahoma Water, Sewage, and Industrial Wastes Conference is active in the training of plant operating personnel needed in the state. In addition to training personnel for operation and laboratory control, this organization provides a voluntary licensing program for operators and acts as a medium for the exchange of information on the methods of solving practical plant problems. The Oklahoma State Department of Health and the Oklahoma A&M College have been active in supporting the programs of this organization. The services of sanitary engineers from the State Department of Health and A&M College, and other competent persons are utilized for instruction at regular district meetings of the Conference. A short course of instruction is also held every year at the A&M College. Engineers and other personnel of the State Department of Health are always available for consultation on plant problems for the purpose of maintaining and improving the efficiency of the pollution abatement facilities in the basin.

TABLE 10*

SEWAGE STUDY DATA FOR TOWNS IN WASHITA RIVER BASIN

General Data

Town	Population Estimate	Estimated Sewered Population	Treatment Plant	Average Flow M.G.D.	Maximum Flow G.P.M.	Gal. Per Capita Daily	Date of Study	Receiving Stream
Anadarko	6,184	6,100	None	0.323		52	Nov. 8, 1948	Washita R.
Chickasha	14,100	9,300	Bar screen, Imhoff tank, filter, drying beds	1.027	751	111	June 12, 1946	Washita R.
Clinton	7,555	7,170	Bar screen, primary settling, filter, digester, drying beds	0.473	574	66	July 23, 1946; May 19, 1951	Washita R.
Cyril	1,000	970	Bar screen, Imhoff tank, filter, drying beds	0.0386	25	40	July 2, 1941	Little Washita R.
Madill	2,791	2,250	Bar screen, Imhoff tank, filter, drying beds	0.155	204	67	Feb. 22, 1951	Big Glasses Creek
Pauls Valley	6,896	4,800	None	.291	322	60	Nov. 2, 1949	Washita R.
Rush Springs	1,402	1,000	Bar screen, septic tank, drying beds	0.0676	79	68	March, 1950	Rush Creek

*From: Oklahoma State Department of Health

TABLE 10 (Continued)

Laboratory Data

	Raw Sewage							Plant Effluent				
	5 day B.O.D.		Suspended Solids		Settleable Solids	pH	D.O.	B.O.D.	Suspended Solids	Settle-able Solids	pH	D.O.
Town	#/Day	#/Cap.	#/Day	#/Cap.	Gal./Day		ppm	#/Day	#/Day	Gal./Day		ppm
Anadarko	532	.080	626	.094	1,580	7.7		Raw Sewage Study only			-	-
Chickasha	2680	.29	2490	.27	6,670	7.26		Raw Sewage Study only			-	-
Clinton	1640	.19	338	.16	4,300	7.0	0	203	235	593	7.44	0.6
Cyril	80.7	.0807	44	.044	182	7.5		7.6	19.5	6.12	8.2	-
Madill	391	.174	404	.179	790	7.3	1.9	84	184	356	7.4	3.3
Pauls Valley	738	.107	336	.049	2,210	7.7		Raw Sewage Study only			-	-
Rush Springs	76.8	.080	78.5	.079	170	7.65	3.74	63.6	62.9	91	7.66	2.46

Plant Efficiency Data

	Primary Removal (%)			Filter Removal (%)		Overall Removal (%)		
Town	B.O.D.	Suspended Solids	Settleable Solids	B.O.D.	Suspended Solids	B.O.D.	Suspended Solids	Settleable Solids
Anadarko	Raw Sewage Study only		-	-	-	-	-	-
Chickasha	Plant by passed at date of study		-	-	-	-	-	-
Clinton	20.1	22.4	86.1	83.4	32.8	88.4	73.2	78.9
Cyril	51.0	70.0	86.7	80	32.5	81.8	79.3	96.7
Madill	23.4	35.6	64.7	71.3	27.7	77.4	52.5	55
Pauls Valley	Raw Sewage Study only		-	-	-	-	-	-
Rush Springs	11.5	13.2	49.9	-	-	-	-	-

TABLE E

ADEQUACY OF EXISTING TREATMENT FACILITIES
MUNICIPAL

Number of Municipal* Treatment Facilities	Adequacy with Relation to:					
	Capacity			Operation		
	Satisf.	Unsatisf.	Undetermined	Satisf.	Unsatisf.	Undetermined
26	3	23	0	6	15	5

*Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers or other population centers.

TABLE F

ADEQUACY OF EXISTING TREATMENT FACILITIES
INDUSTRIAL

Number of Industrial* Treatment Facilities	Adequacy with Relationto:					
	Capacity			Operation		
	Satisf.	Unsatisf.	Undetermind	Satisf.	Unsatisf.	Undetermined
9	3	6	0	9	0	0

*Industries having separate outlets discharging wastes directly to watercourse.

TABLE G

PROGRESS IN CONSTRUCTION OF POLLUTION ABATEMENT FACILITIES

Year	Municipal		Industrial	
	Sewage Treatment Plants Completed	Design Population	Waste Treatment Plants Completed	Amount of Waste Treated (In terms of Equiv. No. People)
1947	0	-	-	-
1948	1	20,000	-	-
1949	1	4,000	-	-
1950	0	-	-	-
1951	3 1/	21,000	-	-

1/ Under construction as of December 1..

POLLUTION PREVENTION MEASURES REQUIRED

The present evaluation of pollution prevention measures required in the basin is based on information which was available at the writing of this report. The needs considered herein are not intended to be complete and final, but are subject to changes and re-evaluation as additional data become available through future studies and investigations. Assembling of the available data pertaining to all aspects of water pollution has exposed deficiencies in the information and defines a definite need and prerequisite necessary to develop a comprehensive program of water pollution control.

Additional data are particularly needed to determine the pollution loads contributed to the streams by oil production and refinery wastes. Supplemental information of this nature is anticipated as a result of an investigation being conducted on the Little Washita River, during 1951-1952, on "The Effects of Oil Field Wastes (Brines) on Aquatic Life." The study has been undertaken by the University of Oklahoma and is sponsored by the State Department of Health with financial assistance from a Public Health Service research grant.

Although there is a substantial number of waste treatment facilities in the basin, a review of the available data indicates there is an immediate need for improvement projects involving a large percentage of the existing plants. A summary of the municipal waste treatment needs is presented in Table H and Map No. 4. The needs represented include five new plants to serve a sewered population of 13,100; enlargements or additions to existing plants serving 25,500 persons; and replacement of eight existing plants serving 7,000 persons. Only two of the existing plants, serving 16,800 persons, are regarded as adequate and require no projects.

Table I and Map No. 5 show the industrial waste pollution abatement needs. Specific waste treatment requirements include five new plants or other control measures, and six enlargements or additions to existing plants. Three industries require no projects, and the needs for one industry are undetermined.

Table J shows the current status of action by municipalities requiring projects for pollution abatement. Eighteen municipalities have taken no action on their needed projects; five have projects in the active planning stage; two have final plans approved; and three projects are under construction.

Similar data showing the status of action on industrial pollution abatement needs are contained in Table K. Three industries are actively planning waste treatment projects, and the status of project needs for nine industries is undetermined.

Table L is a project list for individual municipalities and known industries needing improvements for abatement of pollution. The population served

TABLE H

WASTE TREATMENT NEEDS - MUNICIPAL*

Needs	Number	Population Served by Facilities
New Plant	5 1/	13,100
Enlargement or Additions to Existing Plant	15	25,500
Replace Existing Plant	8	7,000
No Project Required	2	16,800
Undetermined	0	-

*Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers or other population centers.

1/ Includes one community with existing lagoon of adequate capacity, but which will require new plant to provide a higher degree of treatment.

TABLE I

INDUSTRIAL* WASTE POLLUTION ABATEMENT NEEDS

Needs	Number
New Treatment Plant or other Pollution Control Measures	5
Enlargement or Additions to Existing Plant	6
Replace Existing Plant	0
Connection to Municipal Sewer System	0
No Project Required	3
Undetermined	1

*Industries having separate outlets discharging wastes directly to watercourse.

WICHITA RIVER BASIN

MUNICIPAL WASTE TREATMENT NEEDS

FEDERAL SECURITY AGENCY
Public Health Service

53-A

TEXAS
OKLAHOMA
VICINITY MAP
SCALE OF MILES
0 5 0 10 20 30 40
LEGEND:
NO POLLUTION ABATEMENT NEEDS
POLLUTION ABATEMENT NEEDS UNDETERMINED
POLLUTION ABATEMENT NEEDED
POLLUTION ABATEMENT NEEDS INDICATED BY LETTERS APPEARING BELOW POLLUTION ABATEMENT NEEDED SYMBOLS, AS FOLLOWS:
A NEW TREATMENT PLANT OR OTHER POLLUTION CONTROL MEASURES
B ENLARGEMENTS OR ADDITIONS TO EXISTING PLANT
C REPLACE EXISTING PLANT
S CONNECTION TO MUNICIPAL SEWER SYSTEM
NOTE –
Numbers next to symbols or next to each letter represent number of pollution abatement needs in the category designated
SCALE OF MILES
0 5 0 10 20 30 40

53 b

WASHITA RIVER BASIN

INDUSTRIAL

POLLUTION ABATEMENT NEEDS

FEDERAL SECURITY AGENCY
Public Health Service
Division of Water Pollution Control
Map No. 5

TABLE J

CURRENT STATUS OF MUNICIPAL* ACTION ON

POLLUTION ABATEMENT NEEDS

Status of Action	Number of Municipalities*
Inactive	18
Active Planning	5
Final Plans Approved	2
Under Construction	3

*Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers or other population centers.

TABLE K

CURRENT STATUS OF INDUSTRIAL* ACTION ON

POLLUTION ABATEMENT NEEDS

Status of Action	Number of Industries*
Inactive	0
Active Planning	3
Final Plans Approved	0
Under Construction	0
Undetermined	9

*Industries having separate outlets discharging wastes directly to watercourse.

TABLE L

MUNICIPALITIES AND INDUSTRIES NEEDING IMPROVEMENTS FOR ABATEMENT OF POLLUTION

September 1, 1951

Municipality or Industry	Population Served	Present Facilities	Improvements Needed	Remarks
Alex	420	Septic Tank	Replacement	
Anadarko	6,400	None	New Plant	Under Construction
Binger	400	Imhoff Tank	Replacement	
Carnegie	1,650	Imhoff Tank	Replacement	
Cement	840	Imhoff Tank	Enlargement Addition	
Cement Oil Field	--	85% Subsurface Injection	Enlargement Addition	Brine
Chickasha Gas Field	--	None	New Plant	Brine
Cheyenne	1,134	None	New Plant	Bonds voted
Clinton	7,170	Secondary	Enlargement Addition	
Cyril	850	Secondary	Addition	
Anderson-Prichard Oil Corporation	--	None	Undetermined	Refinery waste
Davis	1,500	Septic Tank	Replacement	
Robberson Oil Field Wildhorse Creek	--	50% Subsurface Injection	Enlargement Addition	Brine
Fox Oil Field Caddo Creek	--	60% Subsurface Injection	Enlargement Addition	Brine
Fort Cobb	650	Imhoff Tank	Addition	
Gotebo	450	Secondary	Addition	
NE Hobart Oil Field	--	70% Subsurface Injection	Enlargement Addition	Brine
Hammon	325	Imhoff Tank	Enlargement Addition	
Kingston	481	None	New Plant	
Loody	600	Lagoon	New Plant	
Lindsay	3,000	Imhoff Tank	Addition	

TABLE L - Continued

MUNICIPALITIES AND INDUSTRIES NEEDING
IMPROVEMENTS FOR ABATEMENT OF POLLUTION

September 1, 1951

Municipality or Industry	Population Served	Present Facilities	Improvements Needed	Remarks
Madill	2,000	Secondary	Enlargement Addition	
Marlow	1,800	Secondary	Addition	
Velma Oil Field	--	None	New Plant	Brine
Sholem Alechem Oil Fld.	--	None	New Plant	Brine
Tatums Oil Field	--	60% Subsurface Injection	Enlargement Addition	Brine
Maysville	1,200	Imhoff Tank	Addition	
Mountain View	1,000	Imhoff Tank	Addition	
Pauls Valley	4,500	None	New Plant	Under Construction
Golden Trend Oil Fields	--	None	New Plant	Brine
Pauls Valley State Hosp.	850	Primary	Replacement	
Riverside Indian School	400	Primary	Replacement	
Rush Springs	3,900	Septic Tank	Replacement	
Knox Oil Field	--	70% Subsurface Injection	Enlargement Addition	Brine
Sulphur	3,900	Secondary	Addition	
Tishomingo	1,400	Imhoff Tank	Enlargement Addition	
Verden	500	Imhoff Tank	Addition	
Western Tuberculosis Hospital	425	Secondary	Enlargement Chlorination	
Wynnewood	800	Septic Tank	Replacement	
Kerr-McGee Oil Industries, Inc.	--	None	Undetermined	Refinery Wastes

by present treatment facilities or the population connected to municipal sewer systems without treatment plants is represented as population served. The specific type or description of improvements needed is not shown in the table. The projects have been listed in general categories to allow for some latitude in final recommendations considered desirable to meet local needs.

It is estimated that the initial cost of the required municipal waste treatment facilities in the basin will be approximately $1,000,000. This estimate is based on average construction costs considered reasonable for the region, but should be regarded with reservation to allow for re-evaluation of needs as more complete and specific data become available.

The lack of adequate data regarding the industrial pollution abatement needs, and the complexities involved in determining the type and magnitude of waste disposal facilities precludes an estimate of cost at this time for providing needed industrial projects.

The large amounts of sediment carried by the Washita River and its tributaries make sediment control measures essential in the basin. The measures required should be designed to retain the valuable soils on the farm lands by application of land treatment practices, and by the use of bank stabilization structures along the streams. Allowance for sediment pools in water conservation and other development projects is normally made for the control of sediment reaching the watercourses. The emphasis, however, should be placed on preventing sediment from reaching the streams, rather than providing for its control in the waters. Sediment control is regarded as the responsibility of landowners, local cooperative organizations, and governmental agencies alike, and the effective application of recognized measures requires the cooperative efforts of all private and public agencies doing active work in the basin.

The need for public support is essential for the promotion of a water pollution control program. Although the public is generally aware of pollution in the streams of the basin, the majority are not fully cognizant of the extent of pollution, of the damages resulting from pollution to all water uses, or the benefits accruing from restoration and protection of the waters for productive uses. A program of public education reaching citizens in all walks of life would serve to create greater public demand for pollution abatement in the basin and in the State generally. As part of a general educational program, there should be an expanded program for training of treatment works operators as a step in achieving maximum benefits from existing and new pollution abatement facilities.

Experience has demonstrated the limitations of divided responsibility for the administration of existing State water pollution control laws among several departments of the State government. It is recognized as desirable, therefore, that administrative responsibility be coordinated to assure that all sources of pollution are adequately controlled and that program activities of each agency complement and support those of other agencies concerned.

TABLE 1a
BASIC DATA ON SOURCES OF MUNICIPAL POLLUTION
WASHITA RIVER BASIN
September 1, 1951

Watercourse -- Municipality	River Mile 1/	Population Served by Sewers	P.E. (B.O.D.) Untreated Wastes	Waste Treatment Provided	Adequacy of Treatment Facilities		P.E. (B.O.D.) Disch'd to Watercourse	Treatment Needs	Current Status Municipal Action
					Cap'y	Opr.			
Washita River									
Clinton	473	7,170	7,170	Secondary	Unsat.	Sat.	575	Enlargement	Active Planning
Western T.B. Hospital (Clinton)	473	425	425	Secondary	Unsat.	Unsat.	170	Enlargement Addition	Inactive
Mountain View	407	1,000	1,000	Primary	Unsat.	Unsat.	700	Enlargement	Inactive
Carnegie	385	1,650	1,650	Primary	Unsat.	Unsat.	1,150	Replacement	Inactive
Fort Cobb		650	650	Primary	Unsat.	Undet'd	450	Enlargement	Inactive
Riverside Indian School (Pauls Valley)	173	400	400	Primary	Unsat.	Unsat.	280	Replacement	Active Planning
Anadarko	331	6,400	6,400	None	-	-	6,400	New Plant	Under construction
Verden		500	500	Primary	Unsat.	Unsat.	350	Replacement	Inactive
Chickasha	270	15,000	15,000	Secondary	Sat.	Sat.	1,500	No project	Inactive
Alex		420	420	Primary	Unsat.	Unsat.	290	Replacement	Inactive

TABLE 1a Continued

Watercourse -- Municipality	River Mile 1/	Population Served by Sewers	P.E. (B.O.D.) Untreated Wastes	Waste Treatment Provided	Adequacy of Treatment Facilities		P.E. (B.O.D.) Disch'd to Water-course	Treatment Needs	Current Status Municipal Action
					Cap'y	Opr.			
Lindsay		3,000	3,000	Primary	Unsat.	Unsat.	2,100	Enlargement	Plans Approved
Pauls Valley State Hosp.	173	850	850	Primary	Unsat.	Unsat.	850	Replacement	Plans Approved
Wynnewood		800	800	Primary	Unsat.	Unsat.	560	Replacement	Inactive
Major Creek									
Cheyenne	570	1,133 2/	-	None	-	-	No sewer system	New plant	Under construction
White Shield Creek									
Hammon		325	325	Primary	Unsat.	Undet'd	230	Enlargement	Inactive
North Branch of Quarter-master Creek									
Leedey	523	600	600	None	-	-	600	New Plant	Inactive
Cavalry Creek	434								
Cordell	435	1,800	1,800	Secondary	Sat.	Sat.	180	No project	-
Rainy Mountain Creek	400								
Gotebo		450	450	Secondary	Unsat.	Unsat.	135	Addition	Inactive
Sugar Creek	323								
Binger		400	400	Primary	Unsat.	Unsat.	280	Replacement	Inactive

TABLE 1a Continued

Watercourse -- Municipality	River Mile 1/	Population Served by Sewers	P.E. (B.O.D.) Untreated Wastes	Waste Treatment Provided	Adequacy of Treatment Facilities		P.E. (B.O.D.) Disch'd to Watercourse	Treatment Needs	Current Status Municipal Action
					Cap'y	Opr.			
Delaware Creek Cement		840	840	Primary	Undet'd	Undet'd	588	Enlargement	Inactive
Little Washita River Cyril	270	850	850	Secondary	Unsat.	Sat.	128	Addition	Inactive
Beaf Creek Maysville		1,200	1,200	Primary	Unsat.	Unsat.	840	Enlargement	Inactive
Rush Creek Rush Springs	155	1,000	1,000	Primary	Unsat.	Unsat.	880	Replacement	Active Planning
Pauls Valley	173	4,500	4,500	None	-	-	4,500	New Plant	Under construction
Wildhorse Creek Marlow	128	1,800	1,800	Secondary	Unsat.	Undet'd	270	Addition	Inactive
Sandy Creek Davis		1,500	1,500	Primary	Unsat.	Unsat.	10,505	Replacement	Inactive
Rock Creek Sulphur	110	3,900	3,900	Secondary	Unsat.	Unsat.	1,170	Addition	Inactive
Pennington Creek (Lake Texoma) Tishomingo		1,400	1,400	Primary	Unsat.	Sat.	910	Enlargement	Inactive

TABLE 1a Continued

Watercourse — Municipality	River Mile 1/	Population Served by Sewers	P.E. (B.O.D.) Untreated Wastes	Waste Treatment Provided	Adequacy of Treatment Facilities		P.E. (B.O.D.) Disch'd to Watercourse	Treatment Needs	Current Status Municipal Action
					Cap'y	Opr.			
Glasses Creek Madill		2,000	2,000	Secondary	Unsat.	Undet'd	460	Enlargement	Active Planning
Caney Creek Kingston		677 2/	-	None	-	-	No sewer system	New Plant	Active Planning

*Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers or other population centers.

1/River Mile Above Mouth of Washita River.

2/1950 census population.

TABLE 2a
BASIC DATA ON SOURCES OF INDUSTRIAL* POLLUTION
WASHITA RIVER BASIN
September 1, 1951

Watercourse --- Industry - Location	Type Industry	Type Waste Produced	Treatment or Other Pollution Control Measures			P.E. (B.O.D.) Disch'd to Watercourse	Pollution Abatement Needs	Current Status Industrial Action
			Degree	Adequacy Cap'y	Opr.			
Washita River								
N. Pauls Valley Oil Field - Pauls Valley	Oil Production	Brine	100% to subsurface	Sat.	Sat.	Not applicable	None	-
Kerr-McGee Industries - Wynnewood	Petroleum Refining	Refinery	None	-	-	Unknown	New plant	Undetermined
Cumberland Oil Field - Cumberland	Oil Production	Brine	100% to subsurface	Sat.	Sat.	Not applicable	None	-
Rainy Mountain Creek								
N. E. Hobart Oil Field - Hobart 1/	Oil Production	Brine	70% to subsurface	Unsat.	Sat.	Not applicable	Enlargement	Undetermined
Delaware Creek and Little Washita River								
Cement Oil Field - Cement 1/	Oil Production	Brine	85% to subsurface	Unsat.	Sat.	Not applicable	Enlargement	Undetermined

TABLE 2a Continued

Watercourse --- Industry - Location	Type Industry	Type Waste Produced	Treatment or Other Pollution Control Measures			P.E. (B.O.D.) Disch'd to Watercourse	Pollution Abatement Needs	Current Status Industrial Action
			Degree	Adequacy Cap'y	Adequacy Opr.			
Little Washita River								
Anderson-Pritchard Refinery Cyril	Petroleum Refining	Refinery	None	-	-	Unknown	Undetermined	Undetermined
Chickasha Gas Field - Cement	Gas Production	Brine	None	-	-	Not applicable	New plant	Undetermined
Rush Creek								
Knox Oil Field 17 Rush Springs	Oil Production	Brine	70% to subsurface	Unsat.	Sat.	Not applicable	Enlargement	Undetermined
Rush Creek and Wildhorse Creek								
Golden Trent Dist. - Pauls Valley	Oil Production	Brine	None	-	-	Not applicable	New plant	Active planning
Sandy Creek and Washita River								
E. Pauls Valley Oil Field - Pauls Valley	Oil Production	Brine	100% to subsurface	Sat.	Sat.	Not applicable	None	-
Wildhorse Creek								
Sholem-Alechem Oil Field - Marlow	Oil Production	Brine	None	-	-	Not applicable	New plant	Active planning

TABLE 2a Continued

Watercourse --- Industry - Location	Type Industry	Type Waste Produced	Treatment or Other Pollution Control Measures			P.E. (B.O.D.) Disch'd to Watercourse	Pollution Abatement Needs	Current Status Industrial Action
			Degree	Adequacy Cap'y	Adequacy Opr.			
Velma Oil Field - Velma	Oil Production	Brine	None	-	-	Not applicable	New plant	Active planning
Salt Creek and Wildhorse Creek								
Robberson Oil Field - Robberson 1/	Oil Production	Brine	50% to subsurface	Unsat.	Sat.	Not applicable	Enlargement	Undetermined
Caddo Creek								
Fox Oil Field - Fox 1/	Oil Production	Brine	60% to subsurface	Unsat.	Sat.	Not applicable	Enlargement	Undetermined
Caddo Creek and Wildhorse Creek								
Tatums Oil Field - Tatums 1/	Oil Production	Brine	60% to subsurface	Unsat.	Sat.	Not applicable	Enlargement	Undetermined

* Industries having separate outlets and discharging wastes directly to watercourse.
1/ Developed before 1937.

DIGEST OF OKLAHOMA WATER POLLUTION CONTROL LEGISLATION

General Statement

Legislation in Oklahoma divides authority and responsibilities for water pollution prevention and abatement among the following State agencies: (1) State Department of Health, (2) Planning and Resources Board, (3) Corporation Commission, and (4) Game and Fish Department.

1. State Department of Health

The bulk of the present statutory authority of the Department of Health dates to 1917. Amendments to the Oklahoma water pollution statutes were passed in 1947. Oklahoma statutes relating to water pollution delegate authority to the State Department of Health to deal with all matters pertaining to water supply and sewage treatment facilities. Legal procedures for the investigation and prevention of pollution are given in the laws. Sewage is defined by law as "any substance that contains any discharge from the bodies of human beings or animals, or chemical or other wastes from domestic, manufacturing or other forms of industry." The State Department of Health is authorized to own, operate, maintain, and staff mobile water and sewage laboratories for stream pollution and water and sewage studies.

For the purposes of administering Public Law 845, the Surgeon General of the U. S. Public Health Service has designated the State Department of Health as the water pollution control agency in Oklahoma.

2. Planning and Resources Board

Authority has been delegated in the 1936-37 and 1941 Oklahoma statutes to the Planning and Resources Board to prevent the contamination or pollution of all streams, creeks, lakes, rivers, watercourses, and subsurface waters. Provisions for enforcement of the statutory regulations are made in the laws.

Effective March 10, 1938, the Board published rules and regulations authorized by law for handling and disposal of any oil, oilfield brine, acid water, or other deleterious waste or substance.

3. Corporation Commission

Authority is delegated to the Corporation Commission to control and regulate secondary recovery of oil and plugging and abandoning of oil wells for the protection of fresh water strata and oil and gas bearing formations.

4. Game and Fish Department

A new fish and game code for Oklahoma was passed in 1951. This act revised fish and game laws and included new provisions. Included in the act are regulations concerning pollution of the waters of the State and penalties for the violation thereof. The Game and Fish Department is authorized to initiate legal action against a person, firm, or corporation responsible for the discharge of deleterious substances to any stream, lake, or pond in the State. Provision in the act is made for fines from $100 to $500, and each day or part of day during which pollution is continued is a separate offense.

WASHITA RIVER BASIN
ROGER MILLS
BECKHAM
CUSTER
WASHITA
KIOWA
CADDO
COMANCHE
GRADY
CANADIAN
MCCLAIN
STEPHENS
MURRAY
CARTER
JOHNSTON
MARSHALL
BRYAN
PONTOTOC
GARVIN
OKLAHOMA
Red
Lake
Texhoma
River